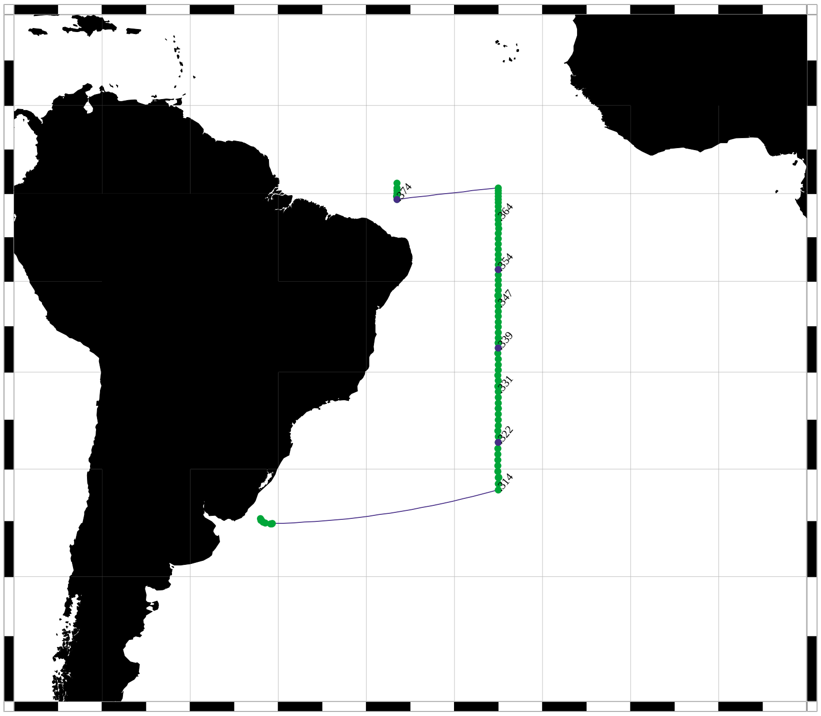
A. Cruise Narrative: A16C

Updated 2004.SEP.14



A.1. Highlights

WHP Cruise Summary Information

WOCE section designation	**A16C**
Expedition designation (EXPOCODE)	**318HYDROS_4**
Chief Scientist and affiliation	**Lynne Talley/SIO**
Co- Chief Scientists	**Mizuki Tsuchiya/SIO** **James Orr/Princeton**
Dates	1989.MAR.13 – 1989.APR.19
Ship	*R/V MELVILLE*
Ports of call	Montevideo, Uruguay to Bridgetown, Barbados
Number of stations	71 CTD/rosette stations 7 Large Volume stations
Geographic boundaries of the stations	0°00.10’N 52°00.90’W 24°57.20’W 35°13.30’S
Floats and drifters deployed	0
Moorings deployed or recovered	0

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WHP Cruise and Data Information

Click to go to text location or use Acrobat® navigation tools. (Shaded headings were not applicable to this cruise or were not available when this report was assembled)

THE UNIVERSITY OF CALIFORNIA AT SAN DIEGO

HYDROS
Leg 4

Physical, Chemical, and CTD Data
R/V MELVILLE
13 March - 19 April 1989

S.I.O. Reference 92-12
April 1992

HYDROS
Leg 4

Physical, Chemical, and CTD Data
13 March - 19 April 1989
R/V Melville

Principal Investigators:
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Data Report Prepared by:

Oceanographic Data Facility
Scripps Institution of Oceanography
University of California, San Diego
April 1992

S.I.O. Reference 92-12

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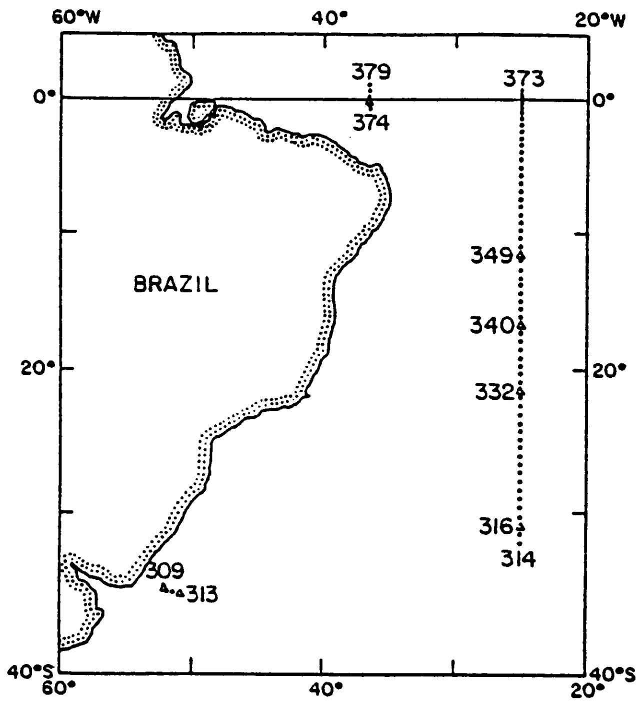
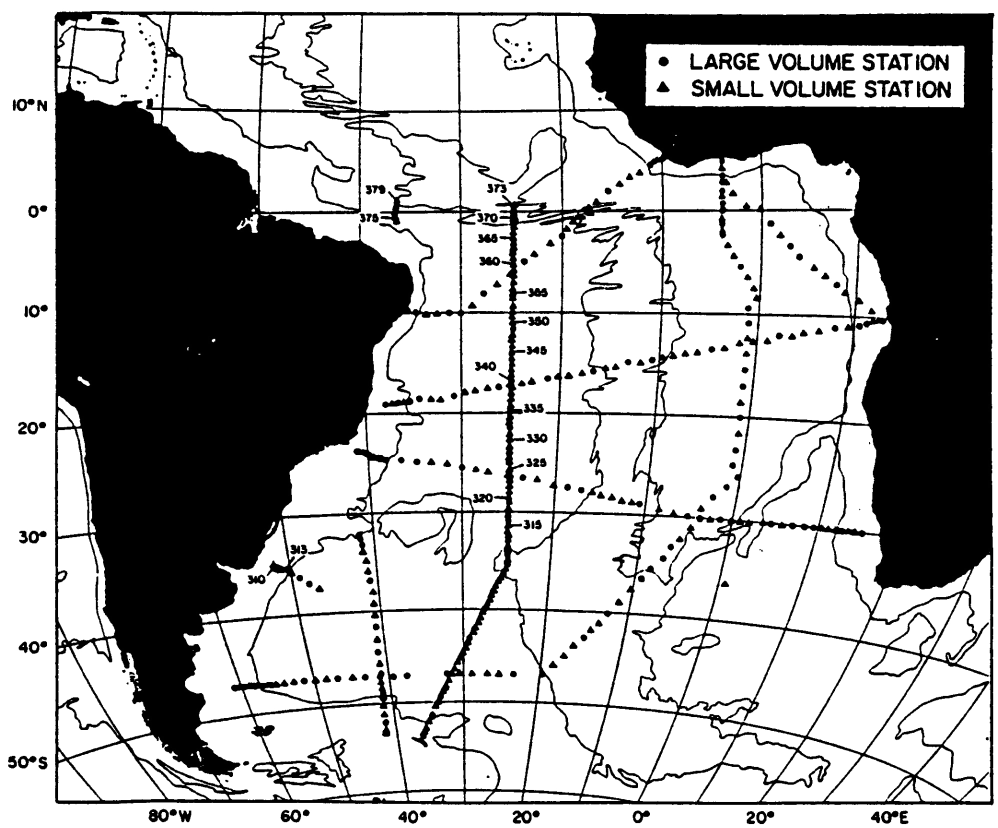
HYDROS Leg 4
Montevideo, Uruguay to Bridgetown, Barbados
13 March - 19 April 1989
Stations 309 - 379

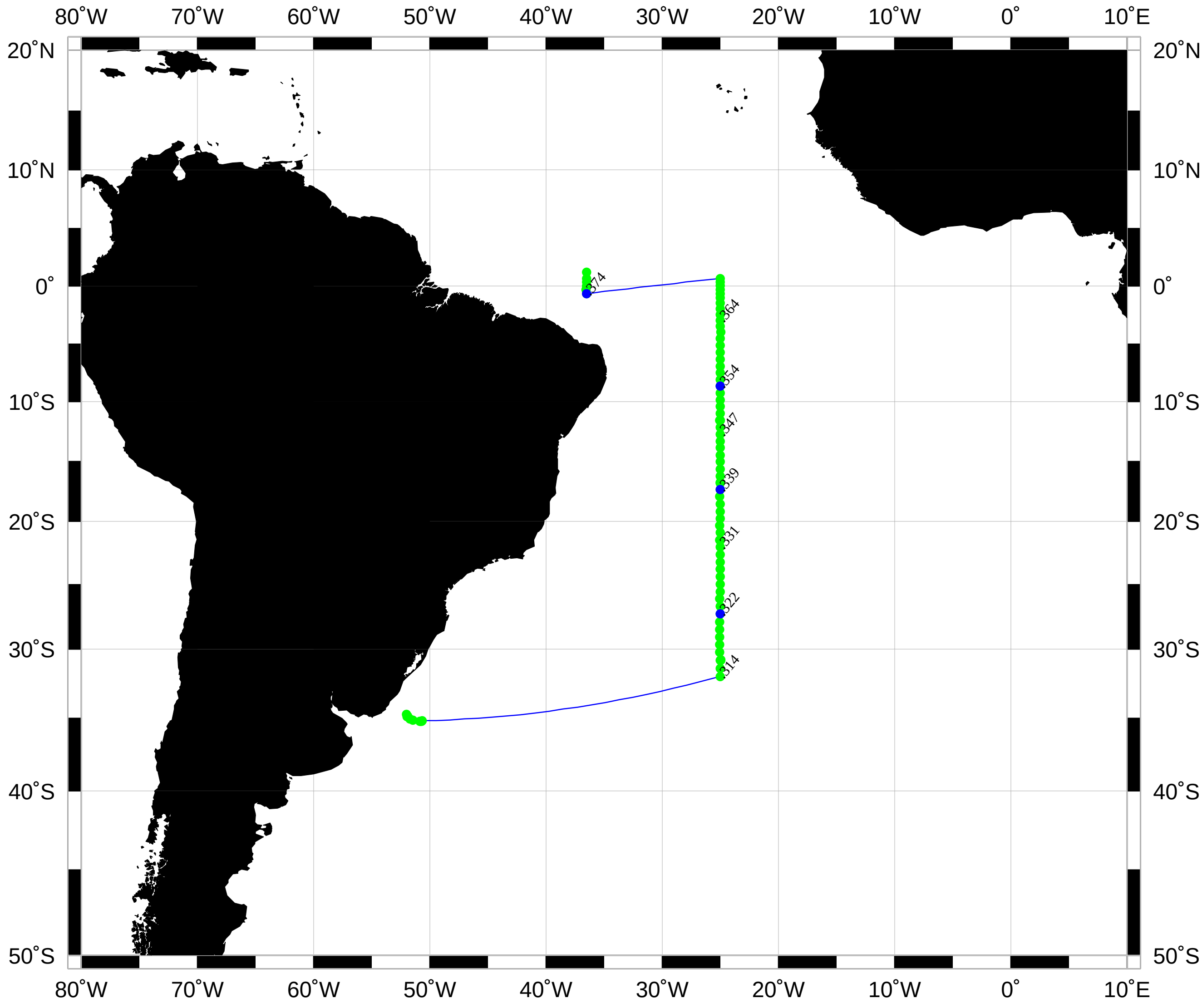




The upper map is Hydros Leg 4 expedition track with CTD/Rosette stations denoted by a dot and Large Volume stations by a triangle.

The SAVE stations (Legs 1-5) are included in the lower map. The actual station numbers and locations can be found in the SAVE publications.

Station locations for A16C • Talley/Tsuchiya/Orr • 1989



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HYDROS
Leg 4
R/V MELVILLE
13 March 1989 - 19 April 1989
Montevideo, Uruguay to Bridgetown, Barbados

Chief Scientists
Dr Lynne D. Talley
and
Dr Mizuki Tsuchiya
Scripps Institution of Oceanography
La Jolla, CA

and

Dr. James Orr
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Princeton, NJ

1. Chief Scientist's Overview

On March 13, 1989 the R/V Melville, under the command of Captain Robert Haines, left Montevideo, Uruguay to undertake hydrographic work first in the territorial waters of Uruguay and then along longitude 25°W from 32°S to 0°40'N, with a final short section across the equator at 36°30'W (see Cruise Track). The ship arrived in Bridgetown, Barbados on April 19, 1989, having completed the entire program with almost no difficulties. Seventy-one CTD/rosette stations were occupied; at 7 sites, large-volume Gerard samples were also collected. The first station number was 309, reflecting the integration of this cruise leg with the South Atlantic Ventilation Experiment (SAVE); Hydros 4 was the sixth and final leg of SAVE and was the fourth and final leg of the 25°W section of McCartney, Talley and Tsuchiya.

Rosette and Gerard station positions are listed in Table 1. For the most part, stations were spaced every 35 nautical miles (na. mi.) with the exception of closer spacing over topography at the western boundary and 20 na. mi. spacing across the equator. Table 1 also lists all properties which were determined from discrete samples collected at each station.

In addition to standard and large-volume hydrographic stations, T-7 XBTs were dropped at 20 na. mi. intervals along the cruise track between stations 313 and 314; surface samples were collected at most locations. Other than along this portion of the cruise track, 1 XBT was dropped each day for regular reporting, as described below. XBT and underway sampling stations are listed in Table 2.

The scientists in charge of CTD/rosette sampling were L. Talley and M. Tsuchiya; J. Orr was responsible for the large volume component.

1.1. CTD/Rosette Sampling

The CTD work and basic water sampling were carried out by Scripps Institution of Oceanography's Shipboard Technical Support/Oceanographic Data Facility (STS/ODF) with help from other members of the science party. D. Muus and J. Boaz were team leaders for the two twelve-hour watches. Rosette handling was optimal with four people on deck and one at the CTD console. Rosette water sampling team sizes varied depending on the number of properties being sampled; the minimum size was 2 (oxygen, salinity and nutrients) and the maximum size was 6 (adding CFCs, helium, tritium, and CO_2).

Sampling at each station included a CTD/O_2 cast with a rosette carrying 36 ten- liter bottles. A single Neil Brown Mark-3 CTD was used throughout the cruise. Also mounted on the rosette frame and connected to the CTD were a transmissometer and a Benthos altimeter. A Benthos pinger with a self- contained battery pack was mounted separately on the rosette frame; its signal was displayed on the precision depth recorder (PDR) in the ship's laboratory. The rosette/CTD was suspended from a three- conductor wire which provided power to the CTD and relayed the CTD signal to the laboratory.

Each CTD cast extended to within 10m of the bottom unless the bottom returns from both the pinger and the altimeter were extremely poor. All 36 bottles were used on stations exceeding 3500m depth. Water samples were collected from the ten-liter bottles for salinity, oxygen, nutrients (silicate, phosphate, nitrate and nitrite), chlorofluorocarbons (CFC-11 and CFC-12), total and partial CO_2, helium-3, and tritium. All but the helium and tritium analyses were done at sea.

CTD data was relayed at 25 Hz, acquired with an ODF deck unit, and partially processed in real time on ODF's Integrated Solutions, Inc. (ISI) computers. Analog data was recorded simultaneously on VCR tapes as a backup. Real-time processing included 0.5 second block-averaging with a filter to remove bad samples; preliminary corrections were applied in real time to the data which were then continuously updated on up to 4 plots displayed on the computer monitor. Immediately after each station, the data were pressure-sequenced and desired plots were produced. During the course of the cruise, M. Johnson of ODF continued the calibration procedures using discrete salinity and oxygen samples collected from the rosette. The CTD temperature calibration was monitored with one rack of reversing thermometers mounted on the second bottle from the bottom; at station 367 a second rack near the bottom was added in order to monitor a drift in temperature difference between the thermometers and the CTD.

Salinity samples were analyzed on two Guildline Autosals by F. Mansir and C. Hallman; oxygen samples were titrated by D. Muus, A. Hester, and M. Tsuchiya; nutrient analyses on a modified Technicon AutoAnalyzer were performed by D. Masten. L. Cartwright reread all of the nutrient charts as part of the usual ODF quality control. D. Muus processed the discrete salinity, oxygen, and nutrient measurements. During the cruise, summaries and plots of all data were available for quality control and interpretation within a day of collection. D. Muus and M. Tsuchiya carefully checked all of the data as it became available. Vertical sections of all parameters were available throughout the cruise. All ODF data were available on the ISI computers for further dynamic computations and mapping throughout the cruise.

The total station time (actual CTD time plus extra time when the Melville was stopped on station during which the CTD was not in the water) on each station was commonly 2 to 4 hours depending on the water depth. The extra time was generally 0.3 to 0.4 hours per station, even in excellent weather which we enjoyed throughout the cruise, because of the relative difficulty of handling the large double rosette package with an 800 lb. weight.

CFC samples were collected at a subset of the stations and were analyzed at sea on two separate systems - for Ray Weiss of SIO and Bill Smethie of Lamont-Doherty Geological Observatory (LDGO). P. Salameh and M. Trunnell operated the SIO system and J. Raznewski the LDGO system. After some initial cross-checking of methods on the two systems, results produced by the two systems on duplicate samples were in good agreement. Plots of all data were available at sea; vertical sections were produced at the conclusion of the cruise using an interface to the ODF system.

Throughout the cruise, air and surface water samples were analyzed every half hour for CH_4, N_2O, and CO_2 by P. Salameh for Ray Weiss.

ΣCO_2 and pCO_2 were made at a subset of the stations for Taro Takahashi (LDGO) by M. Noonan and K. Bosley. Station data plotting was available on the Melville's VAX 730; vertical sections were plotted on the ODF system. At approximately every fourth station, duplicate samples at a pair of surface bottles (4 m) were collected for comparison of the at-sea LDGO measurements with later analysis by C. Keeling at SIO. Four standards prepared in Keeling's laboratory were run during the cruise. At two stations, 15 samples were collected and analyzed for alkalinity. At three stations, air samples were collected for later pCO_2 analysis at LDGO.

Samples for later analysis of helium-3 and low-level tritium were collected at approximately every fourth station by S. Doney for the Jenkins group at Woods Hole Oceanographic Institution (WHOI).

Surface samples for radium analysis were collected near the location of every CTD/rosette station and at approximately 2° longitude intervals along the steam from the last station to Barbados by J. Orr.

1.2 Gerard Sampling

As with SAVE Legs 1-5, large volume samples were collected by Gerard barrel (250-liter) hydrocasts. These samples were often processed sequentially for Krypton-85 (or Argon-39), Carbon-14, and Radium-228. However, for many samples, this complete suite of analyses was not performed because of the different region of interest for each species within water column. Also, each species must be processed and the extract sent to its shore-based analytical facility; different samples quotas are mandated by the different facilities.

Ancillary measurements (on small volumes) for each Gerard cast included salinity (both on Gerards and their attached 5-liter Niskins), temperature (from the reversing thermometer on the 5-liter Niskin), total CO_2 (on each Gerard where C-14 was analyzed), and chlorofluorocarbons (from the five- liter Niskin only for all samples of Kr and from the top and bottom samples of the 6 Gerards tripped for one Ar sample). Unfortunately, no Barium samples were collected from the attached five-liter Niskins because analytical supplies were exhausted during the previous SAVE Leg 5.

Typically, two 9-barrel Gerard casts were taken per station and were separated by one rosette cast. Four people were required on deck for the Gerard barrel handling. Upon arrival on station, first in the water was the deep Gerard cast. For the deep cast, any depths specifically targeted for sampling were selected using the CTD/O_2 profile from the immediately preceding station (usually within 35 na. mi.). Subsequent to the deep Gerard cast, the rosette was deployed and results from its CTD/O_2 trace were used similarly to target depths for the subsequent shallow Gerard cast. Selection criteria included samples from the surface mixed layer, in and around the thermocline at predetermined σ_θ surfaces (25.6, 26.2, 26.5, 26.8, 27.1, and 27.4), the salinity minimum associated with the Antarctic Intermediate Water (AAIW), the salinity maximum-oxygen maximum associated with the North Atlantic Deep Water (NADW) (1700-3000 m), σ_2 = 36.85, and σ_4 = 46.85. Near bottom samples were collected at approximately 20, 150, and 500 m above the bottom. Remaining Gerard barrels were used to "fill-in" gaps, leaving spaces no larger than 400 m between samples; some stations required up to 500 m spacing to adequately cover the water column.

In total, seven large volume stations were taken. The first two were taken while steaming off the Uruguayan slope en route to longitude 25°W. At the first station, 310 in 1091 m of water, one cast of 9 Gerard barrels adequately covered the water column. The second station, station 313 (3066 m), consisted of 3 casts because the more typical 9-barrel surface cast was split into 2 casts of 5 and 4 barrels. This split was initiated to facilitate more processing time for the new Kr-Ar analyst while simultaneously eliminating idle wire time while sitting on this station.

Subsequent large volume sampling occurred only after steaming to 25°W where the ship turned and headed due north. Station 316 (previously referred to as LV1) and station 332 (LV2) were sampled in typical fashion employing shallow and deep casts. Further north along 25°W, station 340 was sampled again with 2 Gerard casts; however, this special station was planned to augment the limited sampling (shallower) feasible during SAVE Leg 2 at the same position; on that leg, only two Gerards were available per cast. Thus station 340, previously referred to as SR1 (SAVE Repeat 1), was sampled with one deep Gerard cast and an additional cast collected near the bottom for Argon-39. Unlike all other stations, station 349 (LV3) necessitated 3 Gerard casts: (1) deep, (2) shallow, and (3) a cast specifically targeted at sampling Argon-39 within the NADW. Finally, station 376 (LV4) was also sampled with the usual 2-cast sampling strategy; however, its original position at the equator along 25°W was shifted to 36°30'W. This shift allowed for sampling of the Antarctic Bottom Water (AABW) by moving from relatively shallow waters overlying the Mid-Atlantic Ridge (between the Romanche and St. Paul Fracture Zones) to the deeper water column above the Ceara Abyssal Plain. The bottom water at 25°W lies at a depth of approximately 3200 db and 2.5°C, while that at the altered position exhibits the presence of AABW with 0.5°C water at its 4500 db bottom.

During Hydros 4, 3 samples were collected for Ar-39 (6 Gerards/sample), 32 samples for Kr-85, 108 for C-14, and 194 for Ra-228 (85 of these were taken from surface soaks, i.e., not via Gerard sampling).

1.3. XBT and Underway Sampling

Except during the initial Uruguayan section, at least one XBT was dropped every afternoon for reporting to the National Oceanic and Atmospheric Administration (NOAA). During the transit from station 313 to 314, an XBT was dropped every 2 hours, for a total of 78 stations at approximately 20 na. mi. spacing. In all cases, T-7 probes were used, extending to a nominal depth of 760 m. Data were acquired by an MK-9 system on the Melville's VAX 730 computer. Plots, isotherm depths, and inflection points were available immediately after each drop. Inflection point data were relayed from the VAX 730 to NOAA each day. M. Moore of STS also produced a separate file of isotherm depths for the closely- spaced section; these were transferred to ODF's system where vertical sections were produced by M. Johnson.

At XBT stations 33 to 74, surface samples were drawn and analyzed for salinity, ΣCO_2 and pCO_2.

1.4. Bottom Depth

An Edo Western precision depth recorder (PDR) was operated continuously during the cruise, except in Brazilian territorial waters surrounding St. Peter and Paul Rocks. The PDR operation was overseen by J. Boaz. An underway watch was maintained to log data every 5 minutes; data were entered on the VAX 730 and merged with navigation for later transfer to the Geological Data Center at SIO. M. Moore also produced Carter- corrected depths for use in plotting the vertical sections. The PDR functioned well in shallow depths and regions of sedimentation. However, along 25°W, the bottom topography was highly irregular and probably rocky; the trace was generally very difficult to follow, despite repeated maintenance.

1.5. Preliminary Results

During the cruise, vertical sections, vertical profiles, printed output and all files on the ODF computers permitted a preliminary look at the data and its implications. In addition, dynamic heights and geostrophic velocities were computed; isopycnal maps of various properties were constructed using all of the SAVE data and several other cruises which had been included in the computer data files. Because it is impossible in this space to describe all of the data or to anticipate all of the uses to which it will be put, only a few selected items are discussed, highlighting what we think are some major new features exposed by the Hydro 4 transect of the Brazil Basin. Isopycnal maps of salinity (at 27.1 σ_θ) and oxygen (at 37.02 σ_θ) constructed from the SAVE, Hydros, AJAX, and 11°S stations illustrate some of these points.

A. Brazil Current (Hydros 4 stations 309-313 and Hydros 3 stations 305-308).

The surface expression of the Brazil Current (upper 1000 dbar) is confined to stations 309 to 312, that is, within 60km of the 200m isobath. (The strong southward current in this region resulted in an arced station "line"). In the upper 1000m immediately offshore of the Brazil Current was a cold/fresh "eddy"; offshore of the cold feature is another warm/saline feature. Thus the circulation in the upper 1000m reflects the meandering and intermingling of the Brazil and Malvinas Currents.

The low salinity AAIW, at about 800 dbar, is clearly split by the strong offshore northward flow: since the AAIW in both the Brazil Current and the offshore cold eddy is much saltier than the AAIW at station 305 and east, it appears that the AAIW in the cold eddy originated in the Brazil Current rather than farther to the south.

Between 1000 and 2000m lies the Upper Circumpolar Water, evidenced by a strong oxygen minimum and NO3/PO4/SiO3 maxima. It is best "developed", with greatest extrema, offshore. It is separated vertically from the Lower Circumpolar Water (LCW) by the unmistakable NADW. The LCW, centered at 3520 dbar, is also an oxygen minimum and is also best developed offshore.

The NADW, between 2000 and 3000 dbar, is an obvious salinity and oxygen maximum. The extrema are highest right at the continental rise, indicating southward flow there.

Just above the bottom, where potential temperature is negative, is a slight but significant salinity minimum, which is also an oxygen maximum. Displaced slightly inshore (at stations 306-308) is a high silicate and nitrate feature, right at the bottom. Its source (direction of flow) is not clear at present, although it is of Antarctic origin.

Geostrophic velocities were computed for the section. An initial reference level at the bottom was used. The initial velocities were compared with the water mass features from which the direction of flow could be deducted. With a reference level at the bottom (deepest common level for a station pair), the velocity profiles matched the deduced water mass flow directions quite nicely. The only questionable flow feature is the direction of the bottom water: placement of a level of no motion at the 0°C isotherm was also tried; this produced weak northward bottom flow with almost no change in velocities through the rest of the column and little change in transport.

Preliminary isopycnal maps, constructed from all SAVE data, at 27.1 σ_θ (AAIW), 36.95 σ_2 (Middle NADW), 37.02 σ_2 (O2 minimum), 45.88 σ_4 (Lower NADW), 46 0 σ_4 (transition), 46.02 σ_4 (AABW), and 46.08 σ_4 (Argentine Basin bottom), confirm that the flow directions acquired from a bottom reference level of no motion are qualitatively correct. The map at 46.08 σ_4 shows no convincing direction of flow; hence the statement in the previous paragraph that the flow direction in this layer is as yet unknown.

Transports were calculated across the short section. Maximum northward transport was 23 Sverdrups between stations 313 and 308; maximum southward transport was 37 Sverdrups between stations 307 and 306. Integrated from the coast to offshore, the maximum southward transport was 45 Sverdrups. Since it is difficult to determine exactly what should constitute the Brazil Current, two definitions are used:

(1) between stations 309 and 312, covering the most intense coastal southward flow, yielding a total of 11 Sverdrups to the bottom, and

(2) maximum southward transport integrated offshore, yielding 45 Sverdrups relative to the bottom or 42 Sverdrups relative to the 0°C isotherm. The maximum southward-integrated transport occurs at station 306. This definition of the Brazil Current therefore includes the southward-flowing NADW and the strong southward surface flow east of the cold intrusion. The northward flow between stations 312 and 308 is included in this total since it is presumed that in this extremely variable region, a large portion of the northward flow is merely returned to the south.

B. Equatorial Region

Of primary consideration here is the section at 25°W. Very obvious in the water mass structure in the equatorial region are: the thermostat of the 13°C water, which extends to 5°S, and 8.5°C "water mass" centered at the equator, the AAIW, the Upper, Middle and Lower NADW, an oxygen minimum separating the MNADW and LNADW, and the AABW.

The 13° water is remarkably well defined on CTD casts, with very abrupt transitions above and below the nearly uniform layer. The "8.5° water" is also fairly well defined and centered at the equator. Both of these water masses may be more a consequence of the local dynamics rather than an indication of a particular formation process. On the other hand, double diffusion may be of some importance in this region in the thermocline, as evidenced by frequent observations of stair- steps at the tropical stations.

An obvious natural feature which affects the equatorial flow at 25°W is the mid-Atlantic Ridge, which rises from the abyssal plain (about 4500m deep) to 3200m at the equator. The rise occurs at about 1°30'S, well within the range of equatorial flow. Since the ridge continues irregularly to the north at this longitude, equatorial flow is forced around the ridge to the south. The most dramatic effect in the vertical sections is the displacement of the high- oxygen core of the Lower North Atlantic Deep Water (LNADW) to the south where it hugs the ridge. It is most strongly developed between 1.7°S and 4°S. The cores of low nutrients associated with the high-oxygen core also show southward displacements from the equator. The effect of the bottom topography also extends to AAIW at much shallower depths, well above the ridge depth. The oxygen and nutrient sections show weakly developed cores of high concentration slightly south of the equator. Oxygen and salinity maps at 27.1 σ_θ show that AAIW flows up the western boundary and spreads eastward at the equator. At 25°W, the core is displaced to the south by the topography.

The UNADW is marked by a salinity and CFC maximum. The most extreme values of each are clearly located south and north of the equator, as if the eastward equatorial flow splits around the topographic barrier. The August, 1988, section at 25°W which extended across the equator to 3°S also showed the cores displaced somewhat to the south, although at that time salinity higher than 34.98psu was found at the equator, with no separate core north of the equator.

The MNADW, marked by an oxygen maximum and nutrient minima at about 2000 dbar (saturation maximum at 1800 dbar), is clearly displaced south of the equator at 25°W.

Another effect of the ridge is to produce a well-mixed layer at the bottom centered at the equator. The layer is about 300m thick and is composed of water from shallower depths, being therefore anomalously warm, saline, light, and oxygenated relative to waters to the north and south at the same depth. This mixed layer is most evident in the CTD oxygen profiles.

The oxygen minimum separating the MNADW and LNADW is well developed only south of the equator. Two factors may be relevant, based on isopycnal maps: (1) eastward flow at this level, carrying high O_2 is directly at the equator and continuous with a core farther west, and (2) the water column is well-mixed at the bottom at the equator, as remarked above, specifically in the part of the column usually occupied by the oxygen minimum.

Finally, an equatorial geostrophic calculation has not yet been made, but the vertical sections of potential density suggest that there might be at least five identifiable layers in the equatorial region (within 4° of the equator). Two additional layers are found south of the ridge, within the equatorial zone (the LNADW and the Antarctic Bottom Water, which have strong density signatures).

C. North Atlantic Deep Water (NADW)

The well known split of NADW into Upper (salinity maximum), Middle (upper oxygen maximum), and Lower (lower oxygen maximum) was recognized and named by Wust (1935). This split is well defined on the short 36°30'W-equatorial section and on the 25°W section from the mid-Atlantic ridge (1.7°S) to about 16°S. The oxygen minimum that separates the MNADW and the

LNADW is associated with a slight minimum or weak vertical gradient of salinity and with clearly defined maxima of SiO_3, PO_4, and NO_3. Salinity and oxygen decrease nearly monotonically at all depths in the NADW from the equator southward to 16°S. In what is perhaps the most memorable feature of the new 25°W data, a strong NADW core reappears at about 18°S, with highest salinity, oxygen and chlorofluorocarbons in a plug between 18 and 25°S. Sections of nutrients also show a core of low concentration in the NADW in these latitudes. The NADW in this region is not clearly differentiated into its three "parts", although the highest salinity is located slightly above the oxygen maximum. It is hypothesized that this strong core is flowing eastward, with its source at the western boundary. This is totally supported by isopycnal maps at intersecting densities, which show a tongue of high oxygen extending southward, from the North Atlantic, along the western boundary to this latitude and then stretching eastward across the Brazil Basin.

Of the isopycnals considered (listed above), the strongest signature of this boundary current and eastward flow is at 37.02 σ_2, which is actually the density of the oxygen minimum splitting the MNADW and LNADW. The isopycnal maps show that the low oxygen north of 16°S originates in the southeastern South Atlantic and is brought northward and westward in broad anticyclonic flow; the high oxygen tongue centered at 22°S is the eastward limb of that flow.

A final remarkable feature of the 25°W section is the extremely sharp transition between the LNADW and AABW in the equatorial region. This undoubtedly results from the proximity to the North Atlantic and the nearly unaltered character of the LNADW.

D. Dynamic Heights and Circulation

Dynamic heights were computed at sea from the CTD data; because the quality of the CTD data is extremely high and because the calibration of the particular CTD used was quite stable throughout the cruise, the final, calibrated results will be similar. Dynamic heights and geostrophic velocities were calculated for all stations along 25°W, including those from Hydros 3 (SAVE 5) between 32°S and 54°S.

Dynamic height at all levels in the upper 1000 dbar relative to any deeper reference level is maximum at 28°S; this then is the center of the subtropical gyre. As is known and is the case in all other ocean basins, the most dramatic fronts, with largest changes in dynamic height, occurs pole-ward of the subtropical gyre center, and are in the eastward flow. The identifiable thermal fronts on this section Hydros 3 along 25°W are: the subtropical front at 28-30°S, the Brazil Current at 42°S, the Subantarctic Front at 45-47°S, and the Antarctic Polar Front at 49-51°S. Even though the strongest fronts occur in the eastward flow, a regular but gentler undulation surface dynamic heights also occurs north of 28°S. The dominant length scale of undulations/frontal spacing from 54°S to the equator is about 4° of latitude (400km) and appears to be independent of latitude. (A similar phenomenon has been observed on a well-resolved meridional section in the eastern North Pacific.)

Because of the undulation in dynamic topography, geostrophic velocities are noisy, reversing constantly along the section. However, the dynamic topography indicates that the predominant large-scale flow north of 28°S is westward, all the way to the equator.

Further work with the velocities has not yet been completed, as this report is being written at the conclusion of the cruise. Because of the noise in the station-to-station velocities, it has not yet been possible to match them with the large-scale intermediate and deep circulations as deduced from the isopycnal maps; in particular the apparent eastward flow of NADW between 19 and 25°S has not emerged. Further work will be forthcoming and results presented in published form.

2. Bottle Data Collection, Analyses and Processing

ODF CTD/rosette casts were carried out with a 36-bottle rosette sampler of ODF manufacture using a General Oceanics pylon. An ODF-modified NBIS Mark 3 CTD, a Benthos altimeter and a SeaTech transmissometer provided by Texas A&M University (TAMU) were mounted on the rosette frame. Seawater samples were collected in 10-liter PVC Niskin bottles mounted on the rosette frame. A Benthos pinger with a self-contained battery pack was mounted separately on the rosette frame; its signal was displayed on the precision depth recorder (PDR) in the ship's laboratory. The rosette/CTD was suspended from a three-conductor wire which provided power to the CTD and relayed the CTD signal to the laboratory. Each CTD cast extended to within 10 meters of the bottom unless the bottom returns from both the pinger and the altimeter were extremely poor. The bottles were numbered 1 through 36. If one of these 36 bottles needed servicing and repairs could not be accomplished by the next cast, the replacement bottle was numbered 71-78. Added CTD levels, no water samples, were assigned bottle numbers 95-99. Subsets of CTD data taken at the time of water sample collection (a 10 second average) were transmitted to the bottle data files immediately after each cast to provide pressure and temperature at the sampling depth, and to facilitate the examination and quality control of the bottle data as the laboratory analyses were completed.

After each rosette cast was brought on board, water samples were drawn in the following order: Freon (CFC-11 and CFC-12), Helium-3, Oxygen, Oxygen-18, pCO_2, SIGMA-CO_2, Tritium, Nutrients (silicate, phosphate, nitrate and nitrite), Salinity and Suspended Particulate Matter. Table 3 is a tabulation of samples collected during all six legs [SAVE Legs 1 through 5 (STS/ODF, 1992) and HYDROS Leg 4 (STS/ODF, 1992)] unless otherwise noted and includes the Principal Investigators and their institutions. Other ancillary program samples were drawn after the core samples. The samples and the Niskin sampler they were drawn from were recorded on the Sample Log sheet. Comments regarding validity of the water sample (valve open, lanyard caught in lid, etc.) were also noted on the Sample Log sheets.

Gerard casts were carried out with ~270 liter stainless steel Gerard barrels on which were mounted 2-liter Niskin bottles with reversing thermometers. Samples for salinity, 14C, 228Ra, 39Ar, and 85K were obtained from the Gerard barrels. The Gerard barrels were numbered 81 through 91 and the piggy-back Niskin were numbered 41 through 70. Surface samples taken from the ship's underway pump line were assigned a bottle number of 98 through 99. Salinity check samples were always drawn from the Niskin bottles for comparison with the Gerard barrel salinities to verify the integrity of the Gerard sample. Occasionally, barium and some of the samples normally taken from the rosette were also drawn from the Gerard-mounted Niskin bottle. These were also recorded on a Sample Log sheet.

The discrete hydrographic data were entered into the shipboard data system and processed as the analyses were completed. The bottle data were brought to a useable, though perhaps not final, state at sea. ODF data checking procedures included verification that the sample was assigned to the correct level. This was accomplished by checking the raw data sheets, which included the raw data value and the water sample bottle, versus the sample log sheets. Any comments regarding the water samples were investigated. The raw data computer files were also checked for entry errors. Investigation of data included comparison of bottle salinity and oxygen with CTD data, and review of data plots of the station profile alone and compared to nearby stations.

If a data value did not either agree satisfactorily with the CTD or with other nearby data, then analyst and sampling notes, plots, and nearby data were reviewed. If any problem was indicated the data value was flagged or deleted. (However, ODF preserves in its archives all bottle data values). Appendix B, the Bottle Data Processing Notes, includes comments regarding deletion of samples.

If it was determined that an entire 10 liter water sample was contaminated by leakage or other bottle or rosette malfunction, the level was reported with just the CTD data (pressure, temperature and salinity). This has been done to preserve the profile and accommodate investigators who prefer using bottle data files exclusively.

2.1. Pressure and Temperatures

All pressures and temperatures for the Niskin bottle data tabulations on the rosette casts were extracted from the processed CTD data, usually those from the corrected 10-second average bottle trip files collected during the up cast (see CTD Data Collection, Analyses and Processing).

Gerard pressures and temperatures were calculated from Deep-Sea Reversing Thermometer (DSRT) readings. Each DSRT rack normally held 2 protected (temperature) thermometers and 1 unprotected (pressure) thermometer. Thermometers were read by two people, each attempting to read a precision equal to one tenth of the thermometer etching interval. Thus, a thermometer etched at 0.05 degree intervals would be read to the nearest 0.005 degrees. Each temperature value is therefore calculated from the average of four readings.

> IT SHOULD BE CLEARLY NOTED THAT THE TEMPERATURES PRODUCED AND PUBLISHED BY ODF IN THIS REPORT ARE BASED ON THE INTERNATIONAL PRACTICAL TEMPERATURE SCALE OF 1968, RATHER THAN THE CURRENTLY USED INTERNATIONAL TEMPERATURE SCALE OF 1990.
> *(The expedition took place before 1 January 1990, the starting date for ITS-90).*

2.2. Salinity

Salinity samples were drawn into ODF citrate salinity bottles which were rinsed three times before filling. Salinity was determined after sample equilibration to laboratory temperature, usually within about 8-36 hours of collection. Salinity has been calculated according to the equations of the Practical Salinity Scale of 1978 (UNESCO, 1981) from the conductivity ratio determined from bottle samples analyzed (minimum of two recorded analyses per sample bottle after flushing) with a Guildline Autosal Model 8400A salinometer standardized against Wormley P-108 standard seawater, with at least one fresh vial opened per cast, or from the corrected CTD conductivity, temperature, and pressure.

Accuracy estimates of bottle salinities run at sea are usually better than 0.002 psu relative to the specified batch of standard. Although laboratory precision of the Autosal can be as small as 0.0002 psu when running replicate samples under ideal conditions, at sea the expected precision is about 0.001 psu under normal conditions, with a stable lab temperature. Still, because a small droplet of fresh water, or the residue from a small evaporated droplet of seawater, can affect a bottle salinity in the third decimal place, and because the Autosal salinometer is sensitive to environmental fluctuations, salinities from bottle samples have a lower true precision under field conditions than in the laboratory. ODF typically deleted the Niskin bottle salinity from this report and substituted the corrected CTD salinity whenever there was any question regarding its validity (see Bottle Data Processing Notes).

2.3. Oxygen

Samples were collected for dissolved oxygen analyses soon after the rosette sampler was brought on board and after CFC and Helium were drawn. Nominal 100 ml volume iodine flasks were rinsed carefully with minimal agitation, then filled via a drawing tube, and allowed to overflow for at least 2 flask volumes. Reagents were added to fix the oxygen before stoppering. The flasks were shaken twice; immediately, and after 20 minutes, to assure thorough dispersion of the $Mn(OH)_2$ precipitate. The samples were analyzed within 4-36 hours.

Dissolved oxygen samples were titrated in the volume-calibrated iodine flasks with a 1 ml microburet, using the whole-bottle Winkler titration following the technique of Carpenter (1965). Standardizations were performed with 0.01N potassium iodate solutions prepared from preweighed potassium iodate crystals. Standards were run at the beginning of each session of analyses, which typically included from 1 to 3 stations. Several standards were made up and compared to assure that the results were reproducible, and to preclude basing the entire cruise on one standard, with the possibility of a weighing error. A correction (-0.014 ml/l) was made for the amount of oxygen added with the reagents. Combined reagent/seawater blanks were determined to account for oxidizing or reducing materials in the reagents, and for a nominal level of natural iodate (Brewer and Wong, 1974) or other oxidizers/reducers in the seawater.

The quality of the KIO_3 is the ultimate limitation on the accuracy of this methodology. The assay of the finest quality KIO_3 available to ODF is 100%, ±0.05%. The true limit in the quality of the bottle oxygen data probably lies in the practical limitations of the present sampling and analytical methodology, from the time the rosette bottle is closed through the calculation of oxygen concentration from titration data. Overall precision within a group of samples has been determined from replicates on numerous occasions, and for the system as employed on this expedition one may expect ±0.1 to 0.2%. The overall accuracy of the data is estimated to be ±0.5%.

2.4. Nutrients

Nutrients (phosphate, silicate, nitrate and nitrite) analyses, reported in micromoles/liter, were performed on a Technicon AutoAnalyzer® The procedures used are described in Hager et al. (1972) and Atlas *et al*. (1971). Standardizations were performed with solutions prepared aboard ship from preweighed standards; these solutions were used as working standards before and after each cast (approximately 36 samples) to correct for instrumental drift during analyses. Sets of 4-6 different concentrations of shipboard standards were analyzed periodically to determine the linearity of colorimeter response and the resulting correction factors. Phosphate was analyzed using hydrazine reduction of phosphomolybdic acid as described by Bernhardt & Wilhelms (1967). Silicate was analyzed using stannous chloride reduction of silicomolybdic acid. Nitrite was analyzed using diazotization and coupling to form dye; nitrate was reduced by copperized cadmium and then analyzed as nitrite. These three analyses use the methods of Armstrong et al. (1967). Sampling for nutrients followed that for the tracer gases, CFCs, He, Tritium, and dissolved oxygen. Samples were drawn into ~45 cc high density polyethylene, narrow mouth, screw-capped bottles which were rinsed twice before filling. The samples may have been refrigerated at 2 to 6°C for a maximum of 15 hours.

3. CTD Data Collection, Analyses and Processing

Hydros-4 was processed with Year-2 of SAVE (Legs 4 and 5), therefore there may be references made to the SAVE Expedition.

71 CTD casts were completed using a 36-bottle rosette sampling system and STS/ODF CTD #1, a modified NBIS Mark III-B instrument. The CTD data were initially processed into a filtered, half-second average time-series during the data acquisition. The pressure and PRT temperature channels were corrected using laboratory calibrations. The conductivity/salinity channels were calibrated to salinity check samples acquired on each cast. The CTD time-series data were then pressure-sequenced into 2-decibar pressure intervals, and the pressure-series oxygen channel was corrected to match oxygen check samples acquired on each upcast.

3.1. CTD Laboratory Calibrations

3.1.1. Pressure Transducer Calibration

Each CTD pressure transducer was calibrated in a temperature-controlled bath by comparison with pressures generated by a Ruska Model 2400 piston gage. The mechanical hysteresis loading and unloading curves were measured both pre- and post-cruise at cold temperature (-1 to 0.5°C bath) to a maximum of 8830 psi, and at warm temperature (28-30°C bath) to a maximum of 2030 psi.

3.1.2. PRT Temperature Calibration

The CTD-1 PRT temperature sensor was calibrated in a temperature-controlled bath by comparison with temperatures calculated from the resistance of a Rosemount Model 162CE standard platinum thermometer, measured by a NBIS model ATB 1250 resistance bridge. The Rosemount standard PRT was checked periodically in water and diphenyl ether triple-point cells. Seven or more calibration temperatures, spaced across the range of 0 to 30°C, were measured both pre- and post-cruise.

3.2. CTD Data Processing

3.2.1. CTD Data Acquisition

Seven data channels (pressure, temperature, conductivity, dissolved oxygen, transmissometer, altimeter and elapsed time) were acquired by CTD-1 at a data rate of 25 Hz. The FSK CTD signal was demodulated by an STS/ODF-designed deck unit and output to an RS-232 bus interface. An Integrated Solutions, Inc. (ISI) Optimum V computer served as the real-time data acquisition processor. .KE

Data acquisition consisted of storing all raw binary data on hard disk, then on magnetic cartridge tape, and generating a corrected and filtered half-second average time-series. Data calculated from this time series were reported and plotted during the cast. A 10-second average of the time-series data was calculated for each water sample collected during the data acquisition.

Generating the half-second time-series data set involved applying single-frame absolute value and gradient filters, then performing a two-pass 4,2 standard-deviation data rejection to all channels. During the acquisition, the pre-cruise laboratory calibration data were applied to pressure and temperature. Pressure, conductivity and oxygen were matched to the thermal response of the PRT temperature transducer. This lag time was determined using raw CTD data from the cruise. The conductivity and oxygen channels were corrected for thermal and pressure effects.

3.2.2. Pressure, Temperature and Conductivity/Salinity Corrections

A maximum of 36 salinity and oxygen check samples, plus 4 thermometric pressure and temperature measurements, were collected during each CTD cast. A 10-second average of the CTD time-series data was calculated for each trip time sample. The resulting data were then used to verify the pre- and post-cruise pressure and temperature calibrations, and to derive CTD conductivity/salinity and oxygen corrections.

3.2.2.1. CTD Pressure Corrections

3.2.2.1.1. CTD #1

The laboratory calibration for CTD-1 at the end of Hydros-4 disclosed a pressure problem affecting all three Hydros (SAVE/Year-2) legs:

a. Although pre- and post-cruise pressure calibrations matched (to within 0.2 decibars) below 1190 decibars, the 0-decibar calibration point differed by 2.5 decibars (loading) and 3 decibars (unloading) between pre- and post-cruise.
b. There was a sudden 6-decibar jump in pressure response between the 1050- and 1190-decibar calibration points on the loading curve during the post-cruise calibration.
c. The jump does not appear in the unloading curve, but shallower than the 1400-decibar point, the post-cruise begins to deviate from the pre-cruise calibration to a maximum of 3 decibars at the 0-decibar calibration point.
d. The post-cruise pressure calibration was repeated, giving similar results.

The pre-cruise calibrations were re-checked, and a smaller/shallower indication of the same problem could be seen on the cold loading curve at 365 decibars. CTD-1 downcasts from all three legs of the cruise were checked for sudden pressure shifts between 800 and 1600 decibars.

The CTD-1 half-second time-series downcasts were checked for a ratio of pressure difference to time difference ("r") greater than 2.5 (equivalent to a winch speed of 150 m/min). For each station with a sudden pressure shift visible on Pressure vs. Time plots, there was exactly one area where r was between 4 and 13. All but six of the jumps occurred between 1000 and 1550 decibars, where the temperature ranged from about 2.5 to 4°C. The other six jumps, between 900 and 1000 decibars, occurred during casts at the beginning of SAVE-4 and at the end of Hydros-4. All detectable rapid changes in pressure occurred in 0.6 to 1.5 seconds and were 1.5 to 10.2 decibars in magnitude.

95 out of 192 CTD-1 casts were affected by a pressure jump as described above. There were problems on many sequential casts, then no detectable problem for many more casts in a row. The pressure at which the jump occurred, and the magnitude of the jump, seemed to be random: there was no apparent correlation to water temperature or elapsed time from the cruise start.

A "baseline" pressure correction curve was generated by averaging the pre- and post-cruise calibration curves for each of the shallow/warm and deep/cold data sets, then removing the 500- to 1500-decibar distortion of the post-cruise calibrations by using the shape of the more typical pre-cruise curve. This averaged out the surface differences and maintained the deep consistency in the calibrations. This average correction curve was used for all casts in which no pressure problem was detected.

Customized pressure corrections were generated for problem casts, as identified by areas of r greater than 3.5. The "baseline" curve described in the previous paragraph was used as the starting point for each cast. The "average" curve was used from the surface to 365 decibars and from the post-"jump" pressure to the bottom. The correction for the beginning pressure of the jump was the post-jump correction value plus the jump size, minus the real pressure change occurring in that time. A straight-line correction was used between 365 decibars down and the beginning pressure of the jump on the cold curve.

The average upcast calibration curves were retained for each cast unless the last corrected in-water surface pressure of an upcast was less than -0.6 decibars. In these cases, the upcast correction curve was adjusted by 0 at 365 decibars to a maximum of +1.5 decibars at the surface, which allowed the curve to resemble the shape of the pre-cruise curve in cases where the end-pressure warranted it.

The corrections applied were intended to correct the distorted pressures to within 2 decibars to maintain the WOCE CTD salinity standards. It should be noted that other problems may still exist, but are not detectable at this time. CTD-1 pressure data above 1600 decibars should not be considered accurate to better than 2 decibars, while deeper data should be within more typical error ranges.

Thermometric pressures collected during the casts were compared with CTD-1 corrected pressure data. Any differences between the two sets of pressures appeared to be rack-dependent.

3.2.2.2. CTD Temperature Corrections

3.2.2.2.1. CTD #1

CTD-1 had a single temperature sensor and was used for stations 186 through 379, except stations 210 and 218. A comparison of the pre- and post-cruise laboratory CTD-1 PRT temperature transducer calibrations showed a shift varying from -.001°C at cold temperatures to -.0017°C at warm temperatures. An average of the two laboratory calibrations was applied to the CTD-1 temperature data.

Thermometric temperature data from the cruise were compared to the calibrated CTD-1 temperature data. Any offsets in the differences tended to correlate with thermometer rack number; no shifts in CTD-1 temperature data could be detected over the course of the cruise.

3.2.2.3. CTD Conductivity Corrections

3.2.2.3.1. CTD #1

Check-sample conductivities were calculated from the bottle salinities using CTD pressures and temperatures. The differences between sample and CTD-1 conductivities at all pressures were fit to CTD conductivity using a linear least-squares fit. Values greater than 2 standard deviations from the fit were rejected. The resulting conductivity correction slope was applied to each CTD-1 cast.

Conductivity differences were calculated for each cast after applying the preliminary conductivity slope correction. Residual conductivity offsets were then computed for each cast and fit to station number. Smoothed offsets were determined in three groups: stations 186-189 (first-order fit), stations 190-202 (0-order/same offset for all casts) and stations 203-379 (0-order/same offset for all casts). The resulting smoothed offsets were then applied to the data, then conductivity slope as a function of conductivity was re-checked - no change was warranted. Some offsets were manually adjusted to account for discontinuous shifts in the conductivity transducer response, or to insure a consistent deep T-S relationship from station to station.

It was noted that stations 190-202 had numerous casts of inconsistent bottle data values caused by a scum buildup in the Autosal cell. Adding to this problem were CTD-1 conductivity offsetting problems caused by sensor fouling on stations 192 and 202. The Autosal was thoroughly cleaned and checked before station 200 deep salts were run, and the CTD conductivity sensor was thoroughly cleaned both before and after station 202. No effect on conductivity values was noted after opening up CTD-1 two separate times to repair the non-functioning multiplexer channel (after stations 192 and 255).

3.2.2.3.2. Bottle vs. CTD Conductivity Statistical Summary

The Hydros (SAVE/Year-2) calibrated bottle-minus-CTD conductivity differences yield the following statistical results:

Cruise leg	Pressure range (dbars)	mean conductivity difference (bottle-CTD mmho/cm)	standard deviation	#values in mean
SAVE-4	all pressures	-.00076	.00578	1944
	allp (4,2rej) *	-.00039	.00227	1805
	press < 1500	-.00113	.00769	991
	press > 1500	-.00034	.00238	952
SAVE-5	all pressures	-.00011	.00400	2311
	allp (4,2rej) *	-.00012	.00137	2176
	press < 1500	-.00002	.00552	1174
	press > 1500	-.00021	.00104	1137
Hydros-4	all pressures	-.00047	.00958	2414
	allp (4,2rej) *	-.00003	.00239	2260
	press < 1500	-.00095	.01354	1200
	press > 1500	+.00002	.00097	1208

* "4,2rej" means a 4,2 standard-deviation rejection filter was applied to the differences before generating the results.

3.2.3. CTD Dissolved Oxygen Data

3.2.3.1. CTD Oxygen Corrections

Dissolved oxygen data were acquired using a Sensormedics dissolved oxygen sensor. The CTD #1 oxygen sensor was used for throughout the expedition.

CTD raw oxygen currents were extracted from the downcast pressure-series data at isopycnals corresponding to the upcast check-samples. The differences between CTD and check-sample dissolved oxygens were used to generate coefficients for the sensor model on a station-by-station basis. Bottle oxygen values were weighted as needed to optimize the fitting of CTD oxygen to discrete bottle samples.

3.2.3.2. Bottle vs. CTD Oxygen Statistical Summary

After the CTD oxygen fitting was completed, the upcast bottle values were compared to the corrected CTD oxygen values. The bottle-minus-CTD oxygen differences resulted in the statistics below:

Cruise leg	Pressure range (dbars)	mean oxygen difference (bottle-CTD ml/l)	standard deviation	# values in mean
Hydros-4	all pressures	+.0004	.0900	2412
	allp (4,2rej) *	-.0005	.0388	2254
	press < 1500	+.0036	.1239	1198
	press > 1500	-.0028	.0306	1215

3.2.4. Additional Processing

A software filter was used on a third of the casts to remove larger conductivity or temperature spiking problems. Additionally, oxygen spikes were filtered out of nearly half of the casts. Pressure did not require filtering. 0.35% of the time-series data were affected by the filter. After filtering, the downcast portion of each time-series was pressure-sequenced into 2-decibar pressure intervals. A ship-roll filter was applied to each cast to disallow pressure reversals.

The remaining density inversions in high-gradient regions cannot be accounted for by a mis-match of pressure, temperature and conductivity sensor response. Detailed examination of the raw data shows significant mixing occurring in these areas because of ship roll. The ship-roll filter resulted in a reduction in the amount and size of density inversions.

3.3. General Comments/Problems

There were 212 CTD rosette casts: three of these (station 178 casts 2 and 3, plus station 328 cast 1) were aborted because of various computer problems, but another CTD cast was done immediately afterward at the same locations. There is one pressure-sequenced CTD data set, to near the ocean floor, for each of 209 stations. The data reported is all from downcasts.

The 0-decibar level of some casts was extrapolated using a quadratic fit through the next three deeper levels. Recorded surface values were rejected only when it appeared that the drift was caused by sensors adjusting to the in-water transition; if there were any question that the that the surface values might be real, the original data was reported.

Several shipboard time-series data sets had areas of missing or noisy data. These casts were recovered by re-digitizing the raw signal from analog tape. A total of 9 data levels were interpolated in 8 casts. The pressures for these interpolated data frames are listed in Appendix A, CTD Processing Notes, along with other shipboard or processing comments regarding individual casts.

During conductivity data calibrations it was noticed that there was an apparent +.002 conductivity offset in the deep data for some stations. This apparent offset appeared in both the downcasts and upcasts for the affected stations. A similar phenomenon has been noticed before in this and other CTDs where the raw conductivity value crosses from 32.768 to 32.767. On some stations, a -.002 shift back appears yet deeper, where the raw conductivity value crosses back over to 32.767 from the other direction. This is a problem specific to certain instruments, and currently there is no correction. It is most noticeable in Atlantic Ocean data because this particular conductivity "crossover" value typically occurs in deep water, where salinity is stable over many hundreds of meters.

The CTD oxygen sensor often requires several seconds in the water before being wet enough to respond properly; this is manifested as low or high CTD oxygen values at the start of some casts. Flow-dependence problems occur when the lowering rate varies, or when the CTD is stopped, as at the cast bottom or bottle trips, where depletion of oxygen at the sensor causes lower oxygen readings. CTD downcast oxygen data are usually smoother than upcast data because of the more constant lowering rate. Any delays or stops during the downcasts that may have similarly affected the CTD oxygen data are documented in Appendix A (CTD Processing Notes).

There were various winch, wire or rosette problems throughout the cruise. These resulted in occasional stops, pauses or yoyos during casts. Only those problems that may have affected the data continuity have been noted. As mentioned above, these changes in the lowering rate can affect oxygen in particular.

4. DATA TABLES AND PLOTS

4.1. Tabular Data, CTD, Rosette and Gerard

Station numbers are consecutive from the beginning to end of the cruise, without interruption. Cast numbers are consecutive at each station, including aborted casts. Meteorological data were collected by the ship's officers and were copied from the Melville's Bridge Log. If more than one CTD cast was done on a station, the deepest cast was reported.

The headings in both the CTD data and ROSETTE and GERARD bottle data have been abbreviated to PRESS, TEMP, and 02 for pressure (decibars), temperature (degrees Celsius), and oxygen (milliliters per liter). In the CTD data listings, specific volume anomaly (centiliters/ton) was abbreviated SVA and calculated according to Millero *et al.* (1980) and Fofonoff *et al.* (1983), Sound Velocity (meters per second) to SVEL, (Chen and Millero, 1977), Dynamic Height (dynamic meters) to DYN HT, (Sverdrup *et al.,* 1942), Vaisala. Frequency (cycles per hour) to VAIS FREQ which uses a subroutine by Bob Millard modified by Lynne Talley to incorporate Gaussian weighting after the formulation of Breck Owens and N. P. Fofonoff. In the bottle data listings, the headings have been abbreviated to SAW NUM and SALT for Sample Number and Salinity (Practical Salinity Units), AOU, P04, N03, SI03, and N02 for apparent oxygen utilization, phosphate, nitrate, silicate, and nitrite (micromoles/kilogram), respectively. Density anomalies in sigma-notation follow the usual practice; e.g. sigma-theta (or sigma-0) is the potential density in kg/m3 referenced to pressure=O, from winch 1000 has been subtracted. Potential temperature, sigma, (degrees Celsius) has been calculated according to Fofonoff (1977) and Bryden (1973) and depth (meters) by Saunders (1981) and Mantyla (1982-1983).

The Gerard data table reports the piggy-back Niskin bottle data and associated Gerard barrel as the sample number with separate columns for the salinity from the two samplers.

Throughout the bottle data report alphabetic characters may be found in the tabular data. These characters have the following meaning:

- D A salinity value, normally from a bottle sample, has been taken from CTD records.
- G Data value appears to be high or low as compared with the station profile, however as compared with CTD trace the sample appears good.
- H A pressure or temperature value, normally from CTD records, has been taken from reversing thermometers.
- L The sample bottle appears to have leaked. This usually refers to Gerard barrels or the piggy-back Niskin and indicates that the samples may be contaminated.
- P The sampler either pre- or post-tripped. This usually refers to Gerard barrels and indicates that the samples may be contaminated.
- U A data value is suspect, although no obvious reason has been found.

Comments and investigation of these values are reported in the Bottle Data Processing Notes section (Appendix B).

4.2. Station Plots (see SIO Pub 92-12)

The hydrographic station plots provide a visualization of the data that is not possible from listings. For each station, the upper plots are CTD data and the lower two plots are bottle data.

5. Acknowledgements

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APPENDIX A: HYDROS Leg 4 CTD Processing Notes

Station	Cast	Remarks
309	1	ODF-CTD #1 w/TAMU transmissometer #100-D; new end termination before leg started
310	1	CTD#1
311	1	CTD#1
312	1	CTD#1
313	2	CTD#1
314	1	CTD#1; 5-day run prior to cast; conductivity sensor soaked in salt water 1 hr prior to station
315	1	CTD#1; 1274-dbar data level interpolated
316	2	CTD#1
317	1	CTD#1
318	1	CTD#1; 1340-dbar data level interpolated
319	1	CTD#1
320	1	CTD#1
321	1	CTD#1
322	1	CTD#1
323	1	CTD#1
324	1	CTD#1
325	1	CTD#1; slip-rings repaired after cast: replaced 2 screws
326	1	CTD#1
327	1	CTD#1
328	2	CTD#1
329	1	CTD#1; 1242-dbar data level interpolated
330	1	CTD#1; winch slowed significantly near cast bottom
331	1	CTD#1
332	2	CTD#1
333	1	CTD#1; inner rosette dropped in rosette room during setup prior to cast
334	1	CTD#1; 1404-dbar data level interpolated
335	1	CTD#1
336	1	CTD#1
337	1	CTD#1
338	1	CTD#1
339	1	CTD#1
340	2	CTD#1
341	1	CTD#1
342	1	CTD#1
343	1	CTD#1
344	1	CTD#1
345	1	CTD#1
346	1	CTD#1; delay cast 10 minutes at 5453 dbars down
347	1	CTD#1
348	1	CTD#1
349	2	CTD#1
350	1	CTD#1
351	1	CTD#1
352	1	CTD#1
353	1	CTD#1
354	1	CTD#1
355	1	CTD#1
356	1	CTD#1
357	1	CTD#1
358	1	CTD#1; last cast with TAMU transmissometer #100-D
359	1	CTD#1; first cast with TAMU transmissometer #102-D

APPENDIX A: HYDROS Leg 4 CTD Processing Notes

Station	Cast	Remarks
360	1	CTD#1
361	1	CTD#1
362	1	CTD#1
363	1	CTD#1
364	1	CTD#1; new cable installed between CTD and transmissometer prior to cast
365	1	CTD#1; back to TAMU transmissometer #100-D
366	1	CTD#1
367	1	CTD#1
368	1	CTD#1
369	1	CTD#1; winch slowed significantly near cast bottom
370	1	CTD#1
371	1	CTD#1
372	1	CTD#1
373	1	CTD#1
374	1	CTD#1; 3-day run prior to cast; conductivity sensor soaked in salt water 1/2-hour, then 45-min delay until cast time; 374-dbar data level interpolated
375	1	CTD#1
376	2	CTD#1
377	1	CTD#1
378	1	CTD#1
379	1	CTD#1

APPENDIX B: Bottle Data Processing Notes

Remarks for deleted or missing samples and footnoted data from HYDROS Leg 4. Uncertainty of data (footnoted data) results in values that may not fit the station profile, but are within the accuracy of the measurement. Investigation of data may include comparison of bottle salinity and oxygen with CTD data, comparison of Niskin/Gerard salinity, review of data plots of station profile and adjoining stations, rereading of charts (i.e., nutrients). CTD data is reported instead of bottle salinity when comments refer to deleted salinity samples or missing for various reasons. Oxygen and nutrient values are referred to in ml/l and µm/l, respectively. On Gerard casts, if there is a comment regarding the Niskin bottle the corresponding Gerard barrel number follows the Niskin number (i.e., 153/183 is Niskin 53 and Gerard 83).

Station 310

260/290 No temperature @30db, off scale, Niskins put on in wrong order. Sample log: Bad Air Leak Niskin-Gerard S -.003 @30db. Gerard sample looks good.

259/282 No temperature @197db, off scale, Niskins put on in wrong order.

251 Sample log: No trip. Reason unknown. No salt or Hydro T & P @1081db. Gerard salt ok.

Station 313

156/186 Sample log: Empty. No temperature or salinity @2510db. "No trip" per temp sheet. No reason given. Sample log: Air leak, big. Niskin-Gerard S .009 at 11db. Calc ok. No temp. Niskin bottles put on in wrong order again.

459/489 No temperature, Niskin bottles put on in wrong order again.

Station 314

113 Hydro O_2 .3 high at 697db compared to CTDO. Calc ok. Probably titration or drawing error. Delete bottle oxygen (5.49)

128 ΔS .011 low at 2803db. Calc ok. Possible dupe draw from Niskin 27. Delete bottle salinity (34.882).

Station 315

101 Sample log: Spigot broken-no water; not discovered until end. No water samples @6db, but there is a duplicate level.

129 Hydro O_2 .05 high at 3201db vs. CTDO. Calc ok. Assume bad titration or draw. Delete bottle oxygen (5.79).

Station 316

188 Sample log: Came up without valve cap (open) (gone). No C-14 or TCO2 drawn from Gerard 88 @4304db.

359 Sample log: Leaked with valve closed. Niskin-Gerard S .001 @1161db. Assume air leak. Gerard sample ok, freon taken from Niskin 59, but no O2.

Station 318

171 Sample log: Lost spigot when being pulled apart. No water samples @109db.

113 Sample log: No sample for salt. No reason given, salt bottle# logged @824db

124 NO_3 about 1.0 low @2991db. AA NO_3 data erratic. Shallower samples were rerun and appear correct per adjacent stations. Deeper samples not rerun. Delete nitrate value (21.4).

127 NO_3 3 low @3613db. See 124. Delete nitrate value (21.4).

129 NO_3 1 low @4030db. See 124. Delete nitrate value (25.4).

130 NO_3 2 low @4237db. See 124. Delete nitrate value (26.1).

131 NO_3 2 low @4445db. See 124. Delete nitrate value (27.1).

132 NO_3 1 low @4654db. See 124. Delete nitrate value (27.9). ΔS .005 high at 4653. Calc ok. CTD S gradient normal. Possible dupe draw from Niskin 31. Delete bottle salinity value (34.760).

133 NO_3 3 low @4863db. See 124. Delete nitrate value (27.1).

134 PO_4 & Silcate low. Calc ok & peak fair. Rechecked per Miki Tsuchiya Feb 25, 1991 note. Peaks definitely decrease on lowest 3 samples; shapes not perfect but are as good as other PO_4 & Siclate peaks this station. Can't guarantee they are "real", may have been some sampling or analysis problem not noted on data sheets. Suggest footnote "U".

135 PO_4 & Silcate low. Calc ok & peak fair. Rechecked per M. Tsuchiya Feb 25, 1991 note. See 134. Suggest footnote "U".

136 PO_4 & Silcate low. Calc ok & peak fair. Rechecked per M. Tsuchiya Feb 25, 1991 note. See 134. Suggest footnote "U".

Station 319

102 Keeling sample @5db, no salinity or oxygen.

116 Sample log: Empty-- bottom lanyard of #36 caught in end cap. No water samples @1196db.

131 PO_4 about 1.5 low @4199db. AA problem, rerun agrees with original. 31 thru 36 low with no reruns**.** Delete phosphate value (1.82).

132 PO_4 @4648db same as 131**.** Delete phosphate value (1.88).

133 PO_4 @4855db same as 131**.** Delete phosphate value (1.92).

134 No nutrients @4795db. Sample tube empty per nutrient data sheet, ok per sample log.

135 PO_4 @5270db same as 131**.** Delete phosphate value (1.96).

136 PO_4 @5423db same as 131**.** Delete phosphate value (2.00).

Station 320

133 NO_3 & PO_4 slightly low. Calc ok. NO_3 peak ok, PO_4 peak fair. Rechecked per Miki Tsuchiya 25 Feb 91 note. Lowest 4 peaks have uniform height. May have been unknown sampling or analysis problem not noted on data sheets. Suggest footnote "U".

134 NO_3 & PO_4 slightly low. Calc ok. NO_3 peak ok, PO_4 peak fair. Rechecked per M. Tsuchiya 25 Feb 91 note. See 133. Suggest footnote "U".

135 NO_3 & PO_4 slightly low. Calc ok. NO_3 peak ok, PO_4 peak fair. Rechecked per M. Tsuchiya 25 Feb 91 note. See 133. Suggest footnote "U".

136 NO_3 & PO_4 slightly low. Calc ok. NO_3 peak ok, PO_4 peak fair. Rechecked per M. Tsuchiya 25 Feb 91 note. See 133. Suggest footnote "U".

Station 321

117 ΔS .014 high at 1542db. Calc ok. Gradient normal. Delete bottle salinity (34.685).

122 PO_4 .05 low at 159db. Calc ok. Peak poor. Delete phosphate (1.44).

125 ΔS .004 high at 3196db. Calc ok. CTD S gradient normal. Delete bottle salinity (34.906).

Station 323

101 Keeling sample @4db, no oxygen or nutrients drawn.

132 Salt analyst: loose top, possible evaporation. ΔS .008 high at 4202db. Calc ok. Delete bottle salinity (34.796).

Station 324

114 ΔS .099 high at 925db. Calc ok. Normal gradient. Suspect bad draw or run. Delete bottle salinity (34.454). O_2 about .05 low compared to CTDO down but CTDO up trace differs from down. Calc ok. Silcate about 8.0 high, calc & peak ok. PO_4 & NO_3 have normal gradient.

115 ΔS .024 low at 1027db. Calc ok. Normal gradient. Suspect bad draw or run. Delete bottle salinity (34.381). O_2 about .09 high compared to CTDO but CTDO up trace differs from down. Calc ok. Silcate, PO_4 & NO_3 have normal gradient.

129 ΔS .027 low at 3595db. Calc ok. Same value as Niskin #30, probable dupe draw. Delete bottle salinity (34.843).

130 Oxy analyst: "value may be wrong-operator distraction" O_2 .25 high @3810db. Delete bottle oxygen (5.87).

Station 325

118 ΔS .012 high at 1436db. Calc ok. This salinity bottle also gave bad values on Stations 333 and 337. Delete bottle salinity (34.702).

Station 326

129 Sample log: No water-lanyard hung up on top. No water samples @4000db.

135 O2 .64 low at 5203db. Calc ok. Assume bad draw, titration or recording error. Delete bottle oxygen (4.55).

Station 327

101 Oxy analyst: no sample Keeling sample @3db, no O_2 or nutrients drawn.

Station 329

1all Salt analyst: "high end warm, possible temp rise in room" ΔSs about .003 lower than adjacent stations for samples 113 thru 136. Possible sample temperature problem plus air temp too high for this Autosal (#4760) which had apparent cooling problem. Delete bottle salinities 113 thru 136.

113 Sample log: Still leaking through end cap when vent is open. ΔS .004 low at 927db. Other water samples also ok. O_2 minimum. Delete bottle salinity @ 927db (34.425).

114 Delete bottle salinity @1029db (34.460).

115 Delete bottle salinity @1132db (34.517).

116 Delete bottle salinity @1234db (34.584).

117 Delete bottle salinity @1337db (34.661).

118 Delete bottle salinity @1440db (34.731).

119 Delete bottle salinity @1645db (34.824).

120 Delete bottle salinity @1852db (34.892).

121 Delete bottle salinity @2059db (34.930).

122 Delete bottle salinity @2265db (34.934).

123 Delete bottle salinity @2471db (34.930).

124 Delete bottle salinity @2679db (34.924).

125 Delete bottle salinity @2886db (34.918).

126 Delete bottle salinity @3093db (34.913).

127 Delete bottle salinity @3301db (34.904).

128 Delete bottle salinity @3509db (34.886).

129 Delete bottle salinity @3717db (34.854).

130 Delete bottle salinity @3925db (34.824).

131 Delete bottle salinity @4133db (34.797).

132 Delete bottle salinity @4342db (34.775).

133 Delete bottle salinity @4550db (34.753).

134 Delete bottle salinity @4758db (34.732).

135 Delete bottle salinity @4967db (34.716).

136 Delete bottle salinity @5134db (34.712).

Station 331

101 Keeling sample @10db, no O_2 drawn.

125 ΔS .010 high at 3296db. Calc ok. Other water samples ok. Similar value to Niskin 24 salt (.002 higher). Possible dupe draw. Delete bottle salinity (34.917).

Station 332

160 Sample log: No water-- not fastened in rack properly. Leaked out bottom end cap. Gerard (190) salt looks ok @5417db.

210 ΔS .043 high at 620db. Calc ok. Normal gradient. Value is .015 higher than value last time this salt bottle was used. Possibly no sample drawn from Niskin 10 and salt bottle reanalyzed. Delete bottle salinity (34.514).

356 Sample log: Vent open unknown time before freon drawn. Note written by freon tech. Niskin-Gerard S .011 at 445db. Calc ok. Normal gradient. Probably poor flush. Leave for now.

Station 333

118 ΔS .043 high at 1337db. Calc ok. Assume bad salt bottle. See Station 325-118 comments. Delete bottle salinity (34.794).

Station 335

101 Keeling sample @4db, no O_2 or nutrients.

110 Sample log: Empty, no water--probable lanyard hang-up on altimeter. No water samples @415db.

Station 336

116 ΔS .077 high at 1029db. Calc ok. Normal gradient. No notes. Assume bad draw or run. Delete bottle salinity (34.595).

Station 337

131 ΔS .007 high at 4546db. Calc ok. Normal gradient. Bad salt bottle. See Station 325 comments, sample 118. Delete bottle salinity (34.764).

Station 338

112 Sample log: Not prepped/no water collected. Air valve & spigot left open @824db.

Station 339

101 Keeling sample @5db, no O_2 or nutrients drawn.

Station 340

156 Salt analyst: only 1/3 bottle sample Niskin-Gerard S -.024 at 2780db. Normal gradient. No note on Sample Log. Gerard value good agreement with CTD S. Possibly salt bottle logged but sample not drawn and this was rerun of last use. Delete bottle salinity (34.873).

160 Niskin salt .04 high at 4628db. Calc ok. Possibly recorded wrong. Delete Niskin bottle salinity (34.778).

229 Sample log: PCO2 bottle lid broken. Note by PCO2 tech. No bottle salinity @4336db.

360 Rack pre-tripped, no temperature @5857db.

Station 343

102 Keeling sample @9db, no O_2 or nutrients.

Station 344

132 ΔS .006 high at 4857db. Calc ok. Normal gradient. Assume bad draw or run. Delete bottle salinity (34.729).

Station 346

106 Special sample for helium and tritium. No oxygen or nutrients drawn @213db.

110 Sample log: Did not trip - lanyard caught on wing nut. No water samples @519db.

112 Sample log: No salt? Line drawn thru salt box on sample log, no reason given. Possibly no water left since 2 freons + full sampling done. NO_3 & PO_4 slightly low at 723db or 113 NO_3 & PO_4 slightly high. Calc & peaks ok.

116 Hydro O_2 .6 low at 1449db compared to CTDO. Calc ok. .02 lower than Niskin 15 O2. Possibly drawn from Niskin 15 by mistake or bad titration. Delete bottle oxygen (4.25).

136 Salt analyst: "loose lid" Calc ok. Probable evaporation. Delete bottle salinity @5721db (34.717).

Station 347

101 Keeling sample @4db, no O_2 or nutrients.

107 Hydro O_2 @212db .9 high compared to CTDO. Calc ok. .04 higher than 106 O2, possibly drawing error. Delete bottle oxygen (3.94).

Station 349

181 Sample log: Suspiciously low salt which places it hundreds of meters shallower (leaky Gerards?). Niskin-Gerard S .084 at 1812db. Rerun confirms low Gerard salt value. No notes re problems with Gerard, and this barrel worked well on preceding and subsequent stations. Niskin salt agrees well with rosette values. Possibly sampling problem. No way of knowing from available data if barrel leaked making argon sample bad or if salt is only problem. Suggest leave low Gerard salt value in report to indicate possible bad sample.

188 Sample log: No salt--insurance barrel/not sampled. No salinity sample @1859db.

192 Sample log: Suspiciously low salt which places it hundreds of meters shallower (leaky Gerards?). Niskin-Gerard S .126 at 1802db. Rerun confirms low Gerard salt value. See sample 181 comments.

212 ΔS 1.104 high at 723db. Calc ok. Other water samples also indicate bottle closed at about 200db. Possibly bottom end cap hung up on CTD clamp. Delete all water samples. (S=35.546, O2=3.77, PO_4=1.26, NO2=0.01, NO_3=16.7, SIO_3=11.4)

220 ΔS .030 low at 2161db. Calc ok. Suspect drawing error. Delete bottle salinity (34.907).

357 Sample log: Not tripped due to lid not high enough. No Gerard (88) check water samples @5259db.

360 Calc ok. No other samples drawn from Niskin. This barrel about 200db deeper than deepest rosette sample. Hydro T @5737db is the same as the barrel above indicating the Niskin salt is wrong since it gives a high density value with the high S. Delete Niskin bottle salinity (34.719).

490 Sample log: Bad air leak. Niskin-Gerard S -.004 at 913db. High gradient. High Gerard value could be from poor flush or leaking Gerard barrel. C-14, salt & Total C02 drawn from this barrel.

Station 350

123 O2 about .15 high @3040db. Calc ok. No notes. Assume bad draw or titration. Flask factor higher but burette reading about the same as same above. Possibly mis-recorded. Delete bottle oxygen (5.94).

124 O2 @3040db about .10 high. Calc ok. No notes. Assume bad draw or titration. Flask factor higher but burette reading about the same as same above. Possibly mis-recorded. Delete bottle oxygen (5.98).

Station 351

101 Keeling sample @11db, no O_2 or nutrients.

Station 355

101 Keeling sample @11db, no O_2 drawn. Sample log also indicates no nutrients, but AA data sheet has reasonable values for tube #1.

Station 356

125 ΔS .016 low at 3505db. Calc ok. Normal gradient. Value similar to Niskin 26, probable dupe draw. Other water samples ok. Delete bottle salinity (34.890).

Station 358

101 Sample log: Water is colder than #2, pylon trigger points at correct slot (#1). ΔS 1.708 low at 0db. All water have same values as Niskin #12 at 722db. Probably rigging problem allowing Niskin #1 to close with Niskin #12. Freon, helium, tritium, PCO2 & TCO2 also drawn and appropriate people notified of problem prior end of leg. Delete all water samples. (S=34.482, O2=3.17, PO_4=2.48, NO2=0.00 NO_3=37.2, SIO_3=31.5).

Station 359

101 Keeling sample @3db, no O_2 or nutrients drawn.

Station 361

125 NO_3 about .5 low at 3083db. Calc ok but poor peak, no rerun. Delete nitrate (20.3).

Station 362

171 Sample log: Air leak. ΔS .007 high at 90db. High gradient. O_2 about 1.0 high compared to CTDO. Calc ok. Nutrients ok, NO2 max. Assume O_2 bad draw or titration. Delete bottle oxygen (5.01).

128 Hydro O_2 .07 high at 3608db. Calc ok. Assume bad draw or titration. Delete bottle oxygen (6.08).

Station 363

101 Keeling sample @4db, no O_2 or nutrients drawn.

110 Sample log: No water-- electrical cable caught in lower lid. No water samples @439db.

111 ΔS .395 high at 566db. Calc ok. Normal gradient. Similar value to Niskin #9 salt. Probable dupe draw. Delete bottle salinity (34.949).

Station 364

110 Sample log: Vent open. ΔS .010 low at 426db. Calc ok. High gradient. O_2 ok compared to CTDO. (O2 minimum). No nutrients. Ok per sample log but AA data sheet says upright & empty. Suspect sampling error.

111 No nutrients @568db. Ok per sample log but AA data sheet says upright & empty. Suspect sampling error.

112 No nutrients @649db. Ok per sample log but AA data sheet says upright & empty. Suspect sampling error.

127 Sample log: O_2 685 broken--noticed at 2nd shake. No hydro O_2 @3503db.

Station 365

126 Sample log: Redo O_2 (within 5-10 minutes) salt, nut sampled before. O_2 compares well with CTDO & adjacent stas. ΔS .020 high at 3089db. Calc ok. Normal, nearly vertical, gradient. Assume bad draw or run. Same value as Niskin 23 salt. Delete bottle salinity (34.931).

Station 368

101 Keeling sample @3db, no O_2 drawn. Sample log indicates no nutrient drawn but nutrient data sheet shows tube #1 run. Data looks ok.

Station 371

128 ΔS .006 high at 1744db. Calc ok. CTD a little bumpy but both down & up S traces show S max close to Niskin 29 at 1847db. Assume bad draw or run. Delete bottle salinity (34.985).

Station 372

108 Hydro O_2 about 1.5 high at 91 db. Calc ok. CTDO shows no inversion this area. Delete bottle oxygen (4.53).

123 Hydro O_2 .2 high at 1434db. Calc ok. Other water samples show normal gradient. ΔS .000. Assume bad draw or titration, or possibly burette reading mis-recorded. Delete bottle oxygen (5.34).

129 Hydro O_2 .07 low at 2255db. Calc ok. CTDO down & up, and other water samples show smooth gradient. O2%sat low & AOU high. Assume drawing or titration error or possibly burette misread. Delete bottle oxygen (5.71).

Station 373

171 ΔS .076 low at 3db. Calc ok. High gradient. Keeling sample @4db, no O_2 drawn. Sample log says no nutrient but nutrient data sheet has reasonable value for tube #1.

Station 375

1all Sample log: Raining hard. This may have contributed to some of the problems described below.

123 Sample log: Oxygen flask 682-bubbles. Hydro O_2 appears about .05 high at 1951db. Calc ok. O_2 data sheet note "B/B", means "big bubble"?. Delete bottle oxygen (5.99).

126 ΔS .005 low at 2571db. Calc ok. Slight CTD S feature but not enough to explain .005 low. Possibly dupe draw from Niskin 27 or rain contamination. Delete bottle salinity (34.935).

Station 376

154 Niskin-Gerard S .021 at 2795db. Calc ok. Gerard S agrees with rosette salts. Niskin 54 salt may have been drawn from Niskin 53. No other samples drawn from Niskin 54. Delete Niskin bottle salinity (34.954).

160 Niskin-Gerard S .009 at 4555db. Calc ok. Possibly sampling error, dupe draw. No other samples drawn. Delete Niskin bottle salinity (34.751).

222 Salt analyst: very little water- 1/2 ΔS .011 high at 1746db. Normal gradient. Delete bottle salinity (35.000).

352 Sample log: "Niskin came up with petcock open and draining." Niskin-Gerard S .09 at 94db. Calc ok. High gradient. Delete bottle salinity (36.096).

Station 377

118 ΔS .006 high at 1387db. Calc ok. CTD S feature, but also same value as Niskin 19 salt indicating possible dupe draw. Delete bottle salinity (34.966).

133 ΔS .003 high at 4023db. Calc ok. CTD S & T break. Calc ok. Nutrients ok. Hydro O_2 .25 high compared to CTDO. Delete bottle oxygen (6.34).

Table 1: Station and Cast Descriptions (see .sum file)

Table 2: HYDROS-4 XBT station positions

Time	Date	Latitude	Longitude	XBT#	Comment
2245z	03/15/89	35°12.40'S	050°42.10'W	XBT#1	DR CHC
0118z	03/16/89	35°09.00'S	050°12.30'W	XBT#2	FAILED DR CHC
0125z	03/16/89	35°08.74'S	050°11.27'W	XBT#3	DR CHC
0300z	03/16/89	35°07.84'S	049°52.27'W	XBT#4	DR DBM
0500z	03/16/89	35°03.84'S	049°27.11'W	XBT#5	SAT DBM
0700z	03/16/89	35°00.50'S	049°02.50'W	XBT#6	DR ECB
0900z	03/16/89	34°56.60'S	048°38.50'W	XBT#7	DR ECB
1057z	03/16/89	34°53.67'S	048°13.66'W	XBT#8	DR CHC
1255z	03/16/89	34°50.49'S	047°53.36'W	XBT#9	DR CHC
1500z	03/16/89	34°48.54'S	047°31.91'W	XBT#10	DR DBM
1700z	03/16/89	34°46.96'S	047°10.73'W	XBT#11	DR DBM
1900z	03/16/89	34°46.56'S	046°48.06'W	XBT#12	SAT ECB
2100z	03/16/89	34°44.25'S	046°22.90'W	XBT#13	DR ECB
2303z	03/16/89	34°40.72'S	046°00.19'W	XBT#14	(dud) DR CHC
2315z	03/16/89	34°39.50'S	045°57.00'W	XBT#15	DR CHC
0100z	03/17/89	34°36.94'S	045°36.28'W	XBT#16	(dud) DR CHC
0115z	03/17/89	34°36.00'S	045°32.50'W	XBT#17	DR CHC
0254z	03/17/89	34°34.63'S	045°12.08'W	XBT#18	DR DBM
0501z	03/17/89	34°35.26'S	044°45.75'W	XBT#19	DR DBM
0701z	03/17/89	34°35.05'S	044°21.07'W	XBT#20	(dud) DR ECB
0721z	03/17/89	34°34.97'S	044°17.09'W	XBT#21	DR ECB
0856z	03/17/89	34°33.09'S	043°57.33'W	XBT#22	DR ECB
1100z	03/17/89	34°28.07'S	043°32.53'W	XBT#23	FAILED DR CHC
1108z	03/17/89	34°28.00'S	043°30.95'W	XBT#24	DR CHC
1300z	03/17/89	34°23.38'S	043°07.00'W	XBT#25	FAILED DR CHC
1315z	03/17/89	34°22.77'S	043°03.87'W	XBT#2?	FAILED DR CHC
1332z	03/17/89	34°22.07'S	043°00.32'W	XBT#26	DR CHC
1459z	03/17/89	34°18.26'S	042°41.86'W	XBT#27	DR DBM
1700z	03/17/89	34°13.74'S	042°15.62'W	XBT#28	DR DBM
1853z	03/17/89	34°09.41'S	041°52.20'W	XBT#29	DR ECB
2051z	03/17/89	34°06.78'S	041°26.51'W	XBT#30	DR ECB
2301z	03/17/89	34°03.33'S	040°58.37'W	XBT#31	DR CHC
0104z	03/18/89	33°59.56'S	040°29.92'W	XBT#32	DR CHC
0257z	03/18/89	33°56.56'S	040°07.28'W	XBT#33	DR DBM
0456z	03/18/89	33°53.47'S	039°42.86'W	XBT#34	DR DBM
0656z	03/18/89	33°50.60'S	039°17.80'W	XBT#35	DR ECB
0854z	03/18/89	33°47.08'S	038°53.20'W	XBT#36	DR ECB
1056z	03/18/89	33°43.28'S	038°27.39'W	XBT#37	DR CHC
1257z	03/18/89	33°40.62'S	038°00.19'W	XBT#38	DR CHC
1505z	03/18/89	33°37.48'S	037°33.12'W	XBT#39	DR DBM
1700z	03/18/89	33°36.64'S	037°06.68'W	XBT#40	DR DBM
1858z	03/18/89	33°23.50'S	036°52.91'W	XBT#41	DR ECB
2100z	03/18/89	33°20.18'S	036°29.82'W	XBT#42	no good DR ECB
2107z	03/18/89	33°19.94'S	036°28.71'W	XBT#43	DR ECB
2304z	03/18/89	33°15.64'S	036°05.57'W	XBT#44	DR CHC

Table 2: HYDROS-4 XBT station positions (continued)

Time	Date	Latitude	Longitude	XBT#	Comment
0059z	03/19/89	33°04.01'S	035°50.29'W	XBT#45	DR CHC
0256z	03/19/89	33°01.36'S	035°24.73'W	XBT#46	DR DBM
0455z	03/19/89	32°58.63'S	034°59.96'W	XBT#47	DR DBM
0659z	03/19/89	32°55.12'S	034°31.90'W	XBT#48	DR ECB
0855z	03/19/89	32°52.51'S	034°06.53'W	XBT#49	DR ECB
1056z	03/19/89	32°50.07'S	033°41.43'W	XBT#50	SAT CHC
1257z	03/19/89	32°48.49'S	033°17.18'W	XBT#51	DR CHC
1505z	03/19/89	32°46.89'S	032°49.27'W	XBT#52	DR DBM
1705z	03/19/89	32°44.21'S	032°23.99'W	XBT#53	DR DBM
1855z	03/19/89	32°31.47'S	032°08.49'W	XBT#54	DR ECB
2058z	03/19/89	32°27.24'S	031°46.22'W	XBT#55	DR ECB
2309z	03/19/89	32°21.48'S	031°23.68'W	XBT#56	DR CHC
0101z	03/20/89	32°11.92'S	031°05.22'W	XBT#57	DR CHC
0258z	03/20/89	32°11.85'S	030°38.69'W	XBT#58	DR DBM
0457z	03/20/89	32°11.41'S	030°09.51'W	XBT#59	DR DBM
0656z	03/20/89	32°10.82'S	029°39.62'W	XBT#60	DR ECB
0857z	03/20/89	32°09.01'S	029°10.69'W	XBT#61	(no good) DR ECB
0910z	03/20/89	32°08.89'S	029°07.77'W	XBT#62	(no good) DR ECB
0920z	03/20/89	32°08.76'S	029°05.65'W	XBT#63	DR ECB
1054z	03/20/89	32°07.38'S	028°42.76'W	XBT#64	DR CHC
1255z	03/20/89	32°06.39'S	028°14.02'W	XBT#65	DR CHC
1501z	03/20/89	32°06.16'S	027°46.64'W	XBT#66	DR DBM
1702z	03/20/89	32°06.41'S	027°23.22'W	XBT#67	SAT DBM
1855z	03/20/89	32°03.95'S	026°57.95'W	XBT#68	DR ECB
2057z	03/20/89	32°01.27'S	026°32.79'W	XBT#69	DR ECB
2300z	03/20/89	31°58.16'S	026°07.72'W	XBT#70	DUD DR CHC
2305z	03/20/89	31°58.22'S	026°06.78'W	XBT#71	DUD DR CHC
2331z	03/20/89	31°58.50'S	026°01.84'W	XBT#72	DR CHC
0100z	03/21/89	31°58.77'S	025°42.87'W	XBT#73	DR CHC
0257z	03/21/89	31°58.50'S	025°20.16'W	XBT#74	DR DBM
0426z	03/21/89	31°57.78'S	025°02.04'W	XBT#75	DR DBM
1954z	03/23/89	27°44.62'S	025°03.33'W	XBT#76	DR ECB
1629z	03/24/89	26°03.90'S	025°01.86'W	XBT#77	DR DBM
1405z	03/25/89	24°13.22'S	025°01.70'W	XBT#78	DUD DR DBM
1415z	03/25/89	24°11.45'S	025°01.55'W	XBT#79	DR DBM
1710z	03/26/89	21°59.03'S	025°01.36'W	XBT#80	DR DBM
1539z	03/27/89	20°50.18'S	025°00.48'W	XBT#81	DR DBM
1352z	03/28/89	18°52.23'S	025°01.05'W	XBT#82	DUD DR DBM
1403z	03/28/89	18°50.26'S	025°00.91'W	XBT#83	DR DBM
1721z	03/30/89	15°37.26'S	025°00.02'W	XBT#84	DR DBM
1406z	03/31/89	13°49.22'S	025°00.28'W	XBT#85	DR DBM
1348z	04/02/89	10°56.64'S	024°59.19'W	XBT#86	DR DBM
1845z	04/03/89	08°25.50'S	024°58.80'W	XBT#87	Deployed DR ECB
1507z	04/04/89	06°52.25'S	024°59.06'W	XBT#88	DR DBM
1423z	04/05/89	04°40.99'S	024°59.84'W	XBT#89	DR DBM
1346z	04/06/89	02°56.81'S	024°59.19'W	XBT#90	DR DBM
1402z	04/07/89	00°59.40'S	024°59.32'W	XBT#91	DR DBM

Table 2: HYDROS-4 XBT station positions (continued)

Time	Date	Latitude	Longitude	XBT#	Comment
1432z	04/08/89	00°38.08'N	025°13.98'W	XBT#92	DR DBM
1725z	04/09/89	00°49.38'N	029°52.05'W	XBT#93	DR DBM
1435z	04/10/89	00°02.59'S	033°24.07'W	XBT#94	SAT DBM
1757z	04/11/89	00°17.34'S	036°31.48'W	XBT#95	Deployed DR ECB

Table 3: Scientific Programs

Participating Institutions	Principal Investigators	Scientific Programs
STS/ODF	Mr. David Wirth Dr. James Swift	Salinity, Oxygen, Nutrients Nitrate, Nitrite, Phosphate, Silicate, CTD Profiles
LDGO MIAMI MIAMI PRINCETON	Dr. Wallace S. Broecker Dr. H. Gote Ostlund Dr. Zafer Top Dr. Robert M. Key	Carbon-14
WHOI	Dr. William J. Jenkins	Helium-3, Tritium
PRINCETON PRINCETON	Dr. Jorge L. Sarmiento Mr. James C. Orr	Radium-228
PRINCETON	Mr. James C. Orr	Radium-226
SIO	Dr. Ray F. Weiss	Freon-11
LDGO	Dr. William M. Smethie, Jr.	Freon-12
PRINCETON	Dr. Robert M. Key	Krypton-85 (LVS), Ra-228 (surface)
BERN LDGO BERN	Dr. Heinz Loosli Dr. William M. Smethie, Jr. Dr. J.H. Oeschger	Argon-39
LDGO	Dr. Taro Takahashi	Total CO_2, pCO_2
LDGO LDGO	Dr. Arnold Gordon Mr. Stanley Jacobs	XBT Profiles
Ancillary Programs		
TAMU	Dr. Wilford Gardner	Suspended Particulate Matter Transmissometer
SIO	Dr. Charles D. Keeling	Total CO_2
SIO/GDC	Mr. Smart M. Smith	Bathymetry
LDGO	Dr. James K.B. Bishop	Barium
SIO	Dr. Ray E Weiss	Underway pN_2O, pCO_2, pCH4 Underway Surface Measurements

Institution Codes:

BERN:	Physics Institute of Bern, Switzerland
LDGO:	Lamont-Doherty Geological Observatory of Columbia University
MIAMI:	University of Miami
PRINCETON:	Princeton University
SIO:	Scripps Institution of Oceanography
SIO/GDC:	Scripps Institution of Oceanography/Geological Data Center
STS/ODF:	Shipboard Technical Support/Oceanographic Data Facility
TAMU:	Texas A & M
WHOI:	Woods Hole Oceanographic Institution

List of Participants

Ship's Captain
Robert Haines • Scripps Institution of Oceanography

Chief Scientist
Lynne D. Talley • Scripps Institution of Oceanography

Co-chief Scientists
Mizuki Tsuchiya • Scripps Institution of Oceanography
James C. Orr • Princeton University

Scripps Institution of Oceanography/ODF
Craig M. Hallman
Arthur W. Hester
Mary Carol Johnson
Forrest K. Mansir
Douglas M. Masten
David A. Muus

Scripps Institution of Oceanography
Peter Salameh
John T. Boaz
Martha Denham
Mike Moore
Xiaojun Yuan

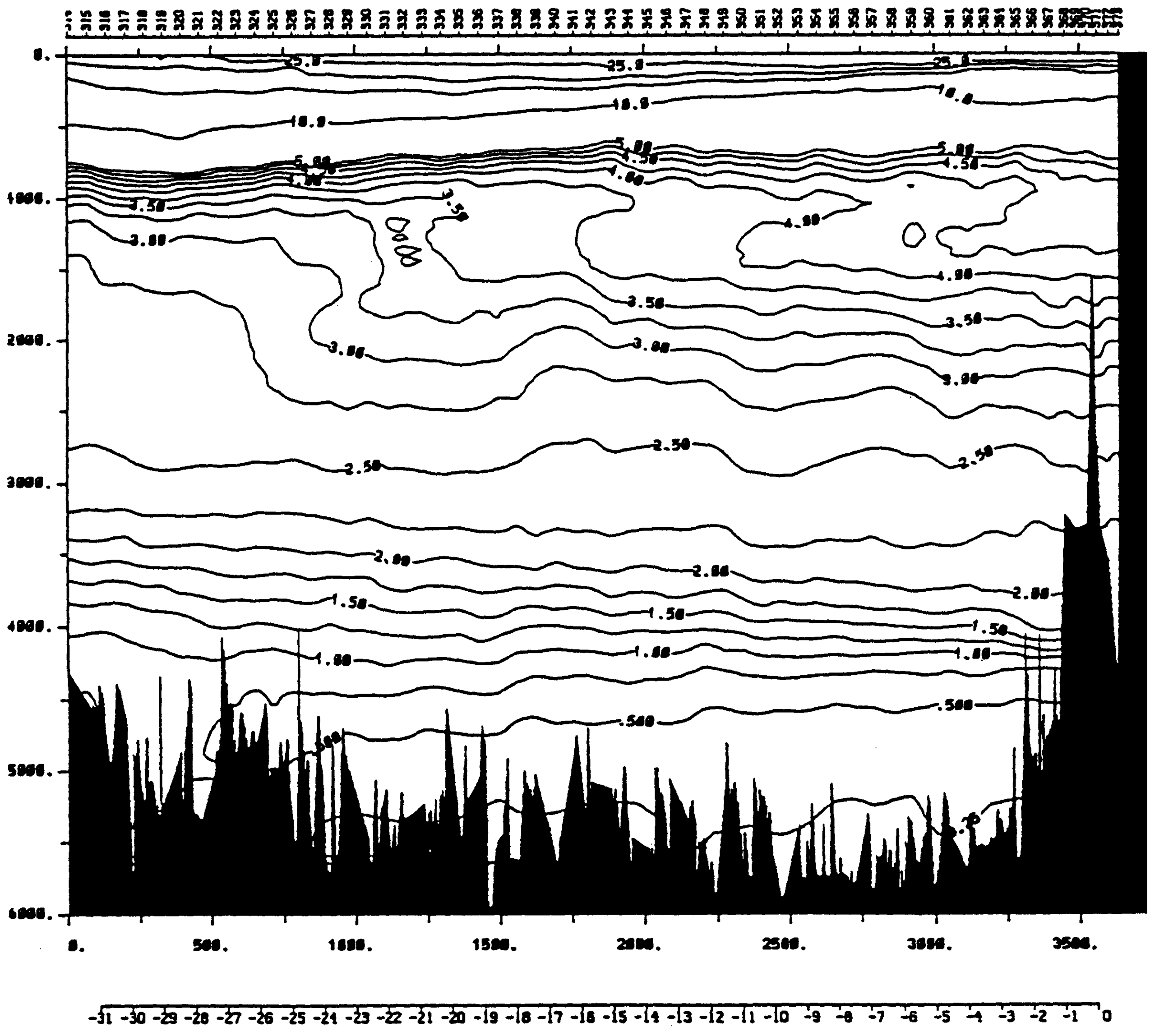
Lamont-Doherty Geological Observatory
Kathryn T. Bosley
Maureen K. Noonan
Jan Razniewski

Woods Hole Oceanographic Institution
Scott C. Doney

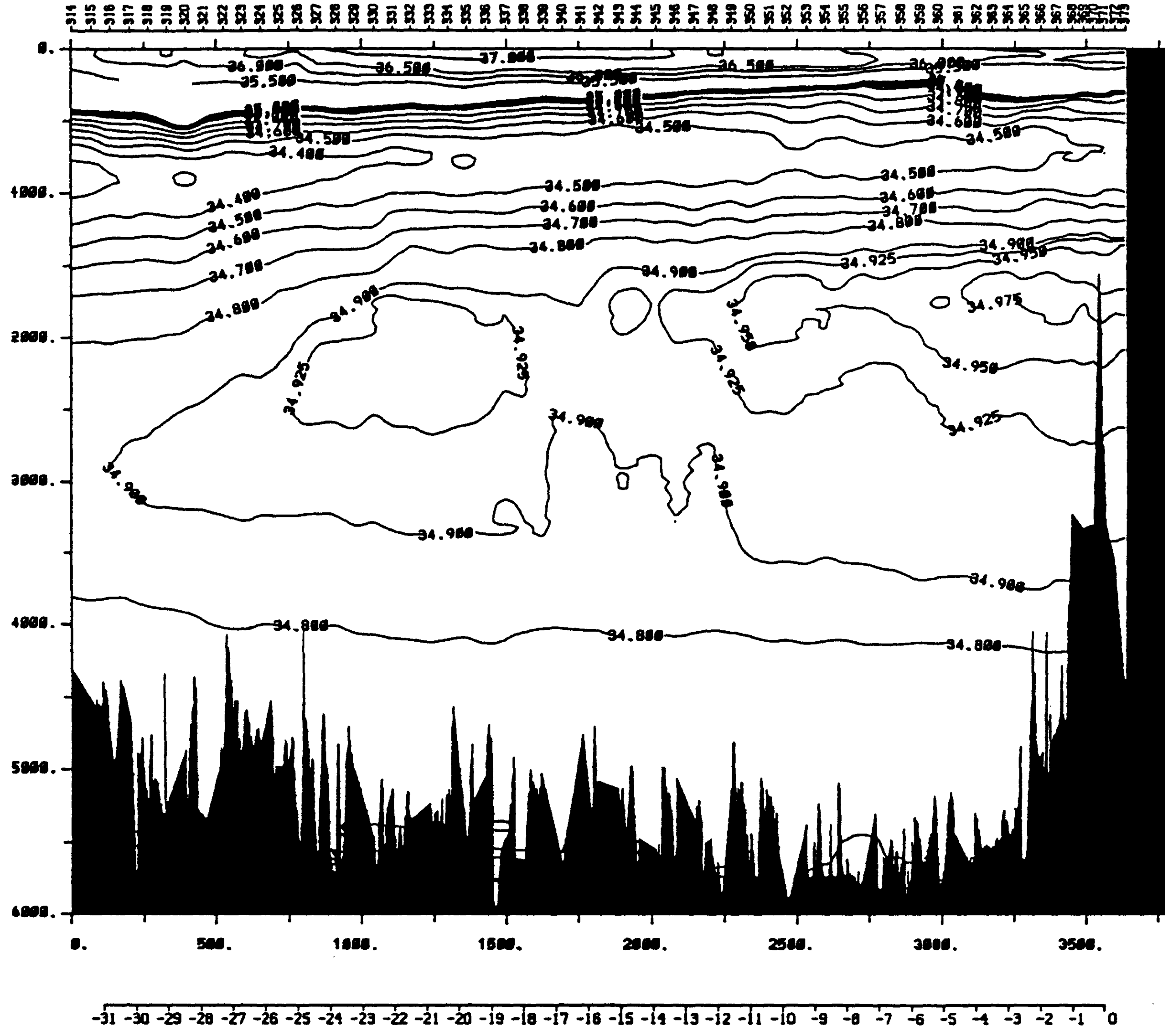
University of Washington
Matthew T. Trunnell

Naval Oceanographic and Hydrographic Service, Montevideo - Observer
Lieutenant Ignacio Barreira-Carrau

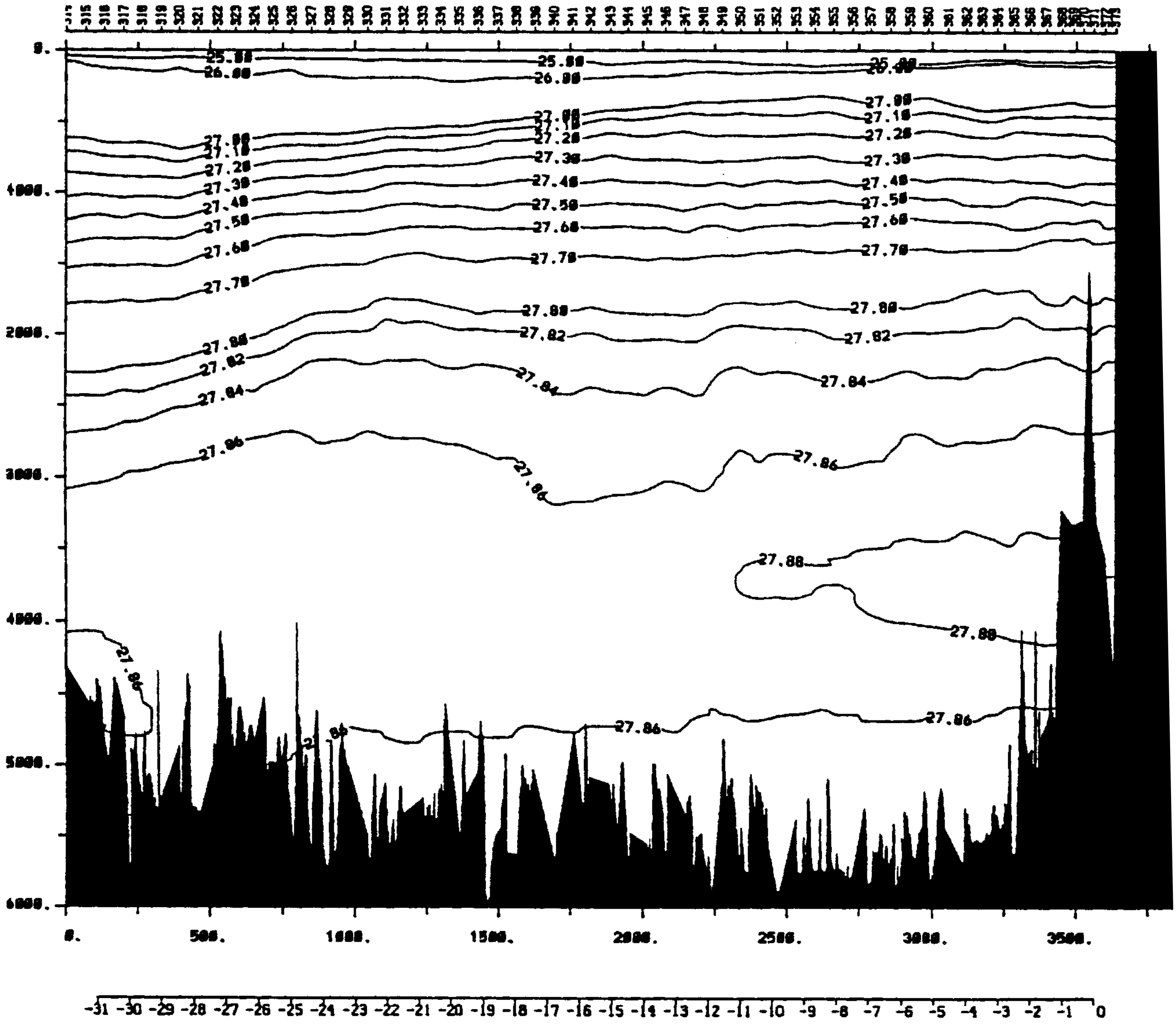
Volunteer: Larry Cartwright



Potential temperature (°C)



Salinity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27.00
27.10
27.20
27.30
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27.50
27.60
27.70
27.80
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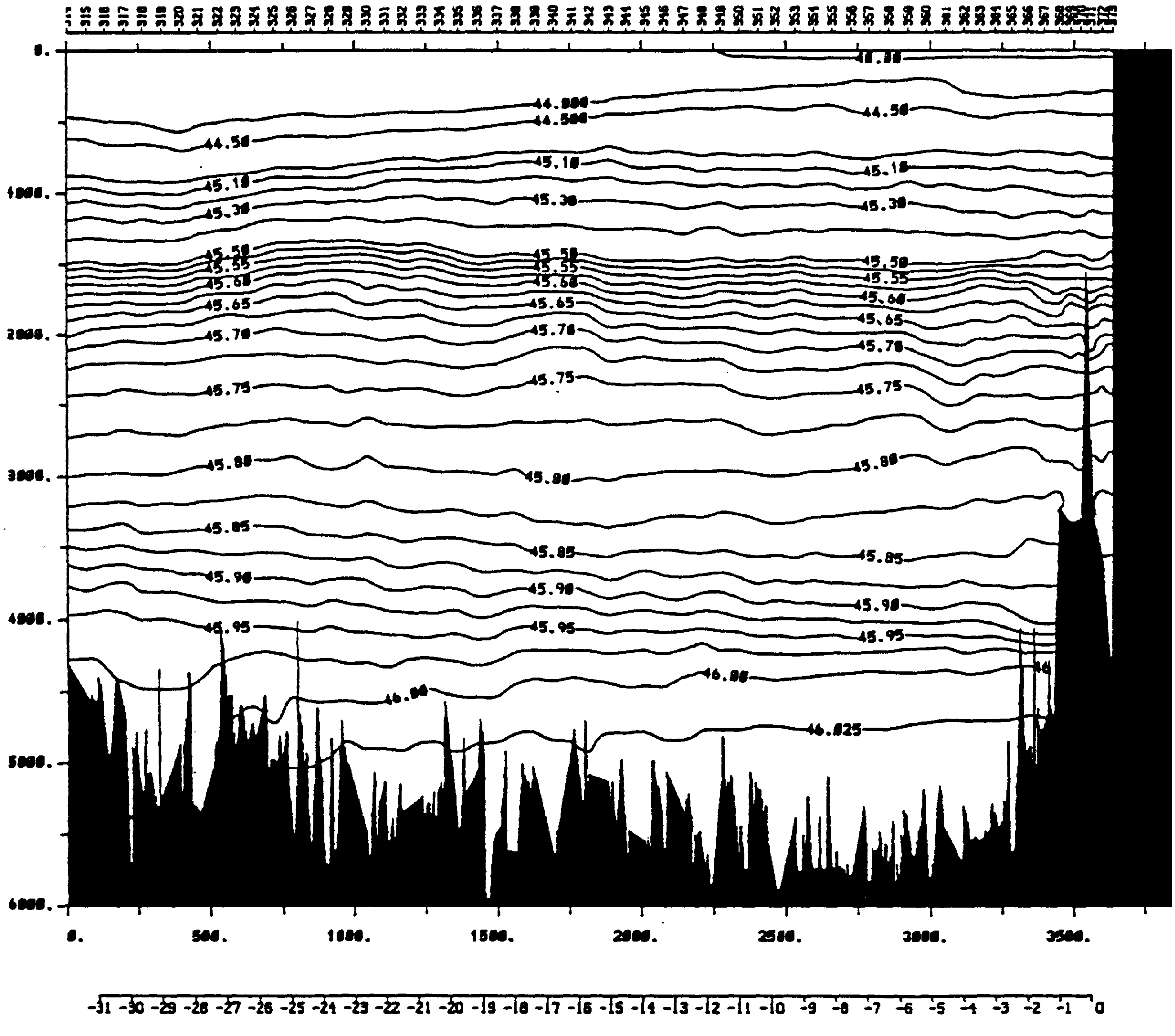
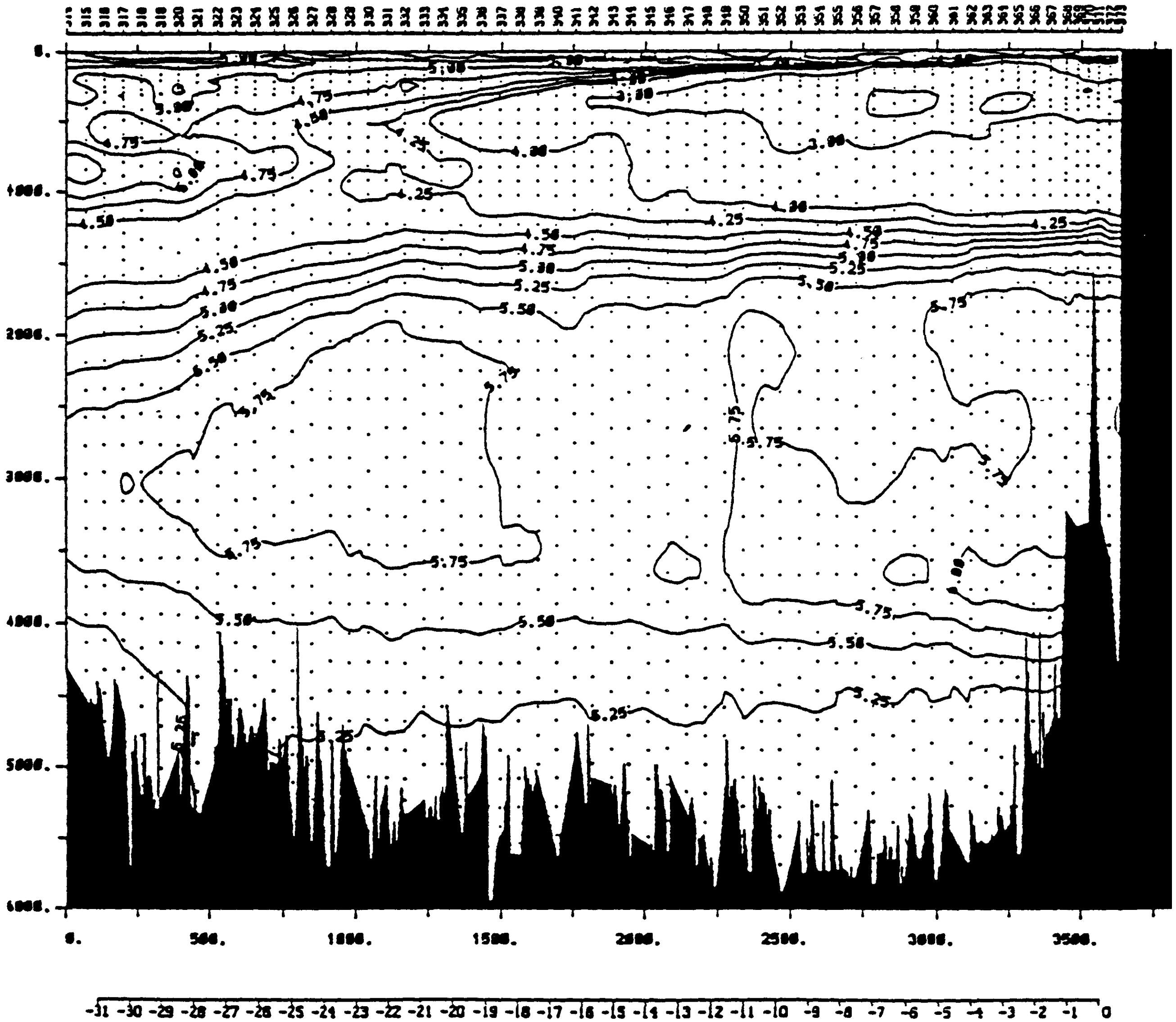
27.84
27.86
27.88
0.
1000.
2000.
3000.
4000.
5000.
6000.
500.
1500.
2500.
3500.
-31 -30 -29 -28 -27 -26 -25 -24 -23 -22 -21 -20 -19 -18 -17 -16 -15 -14 -13 -12 -11 -10 -9 -8 -7 -6 -5 -4 -3 -2 -1 0

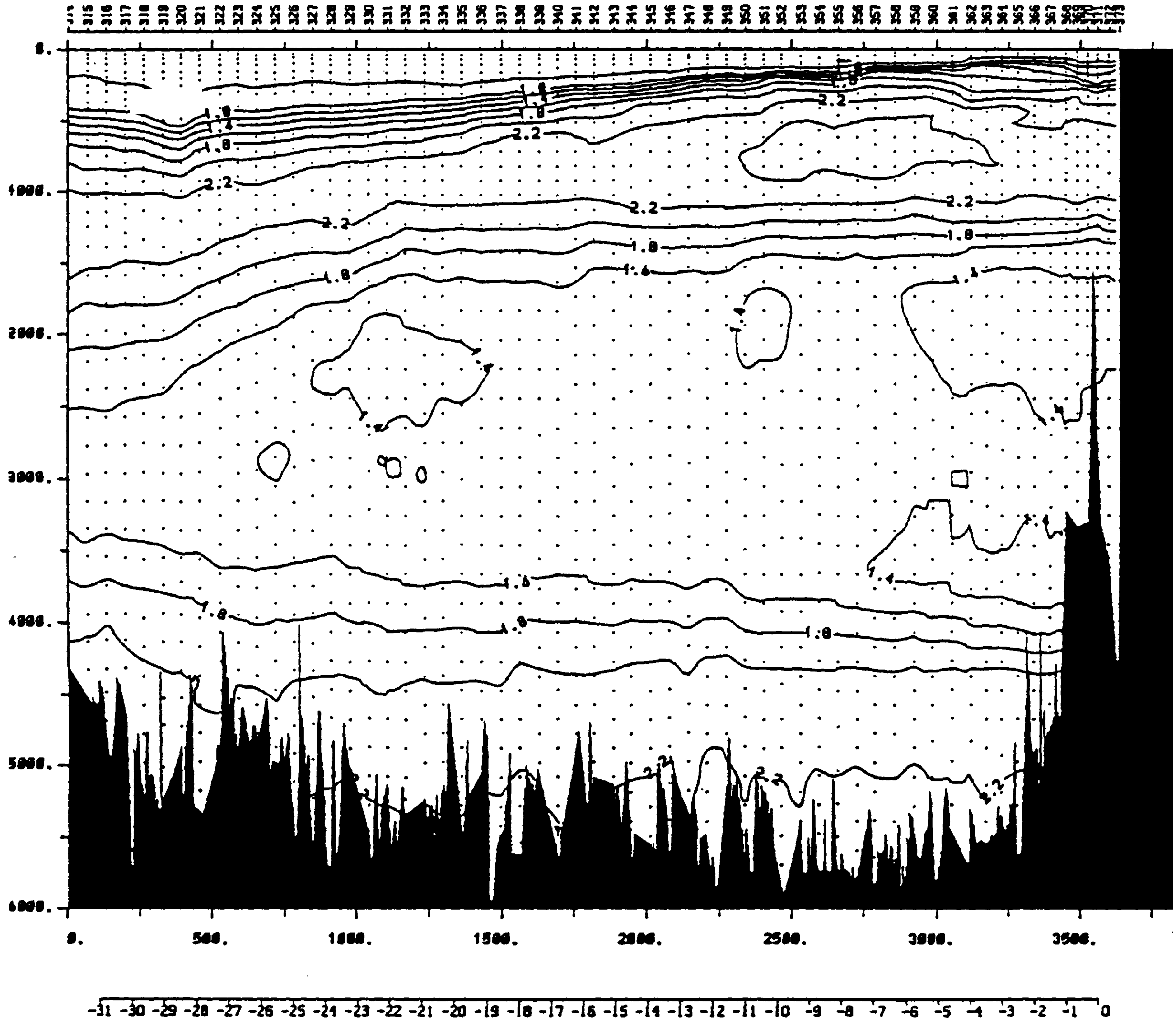
σ_θ



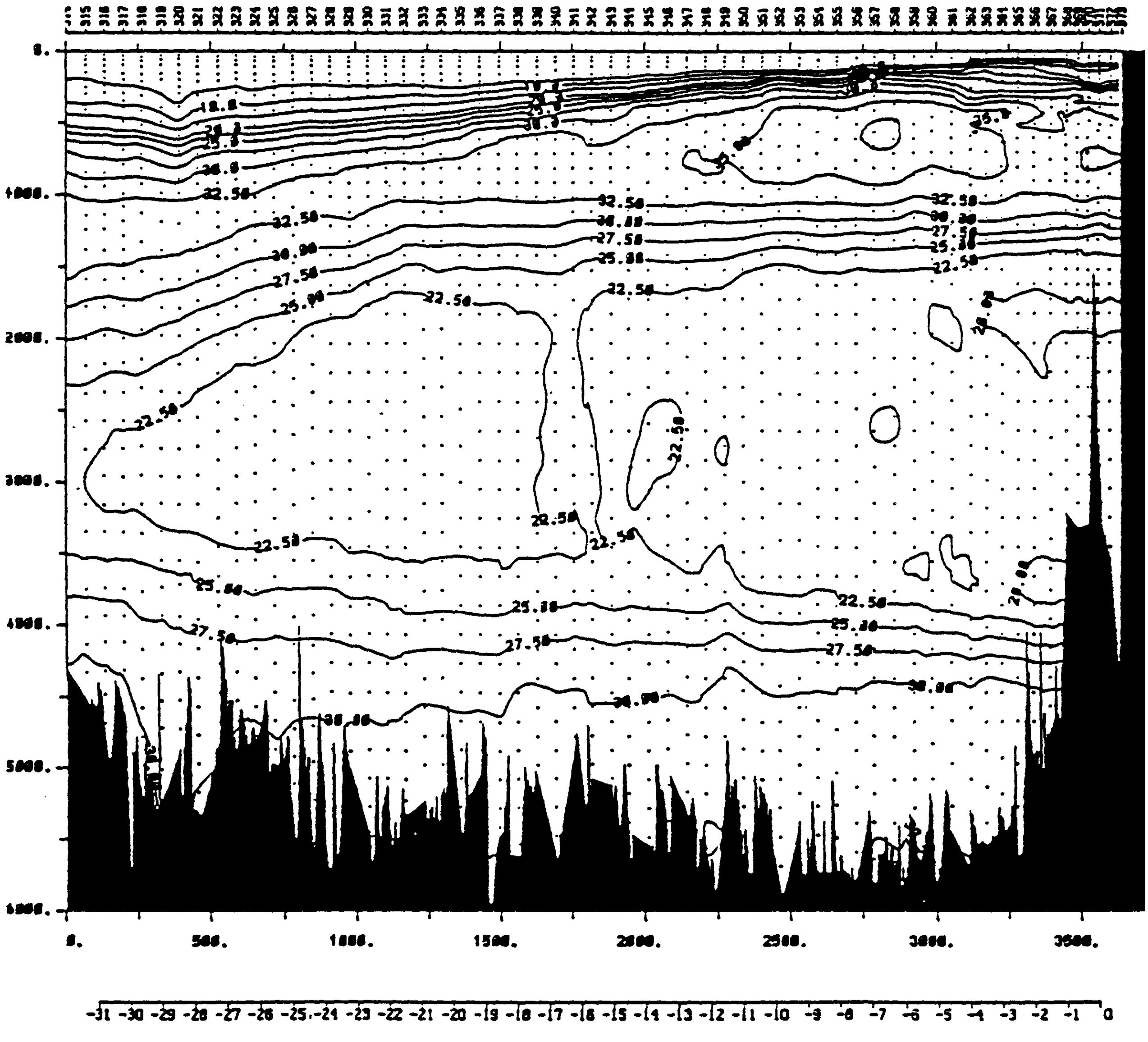
Sigma 4



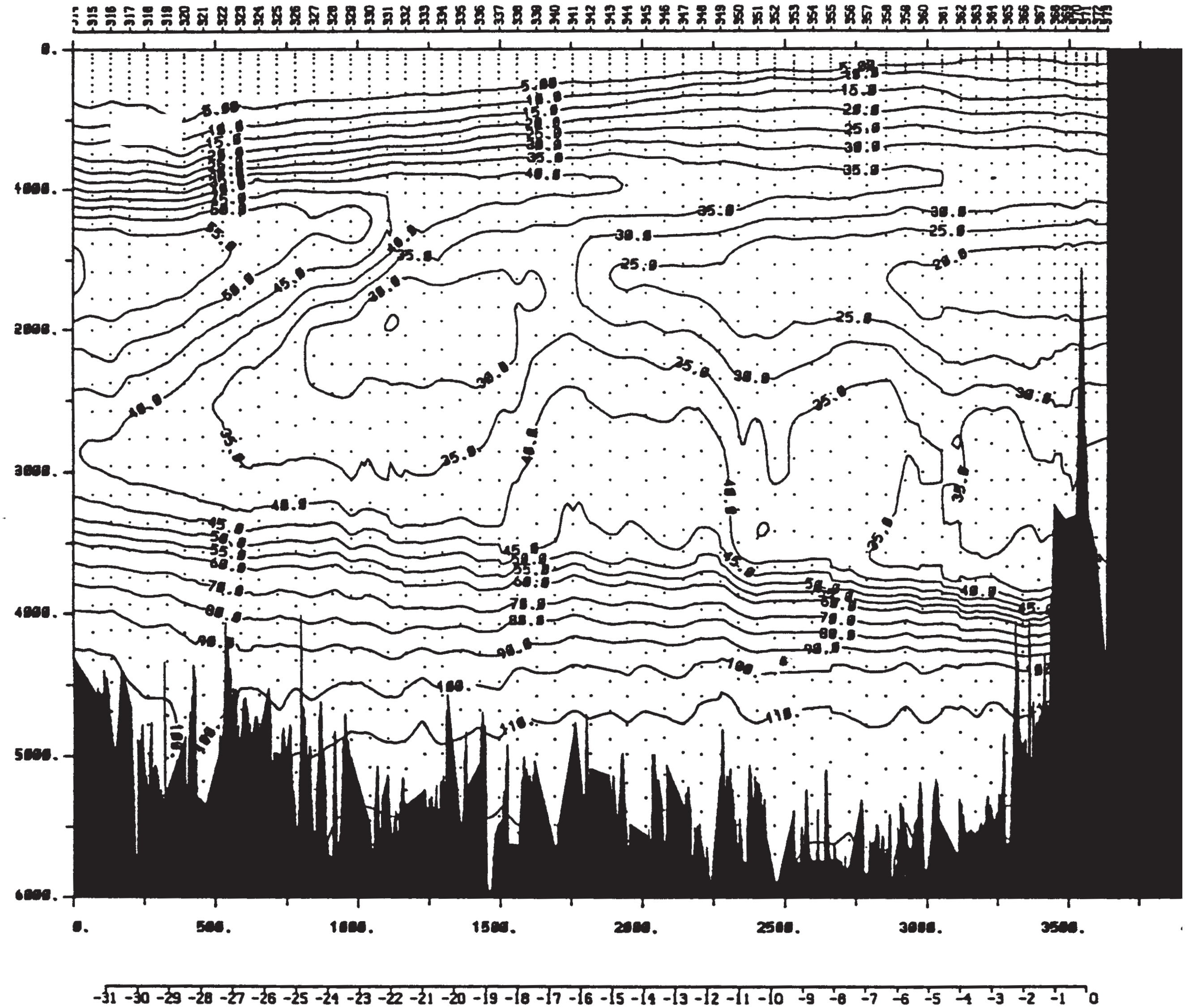
Oxygen (ml/l)



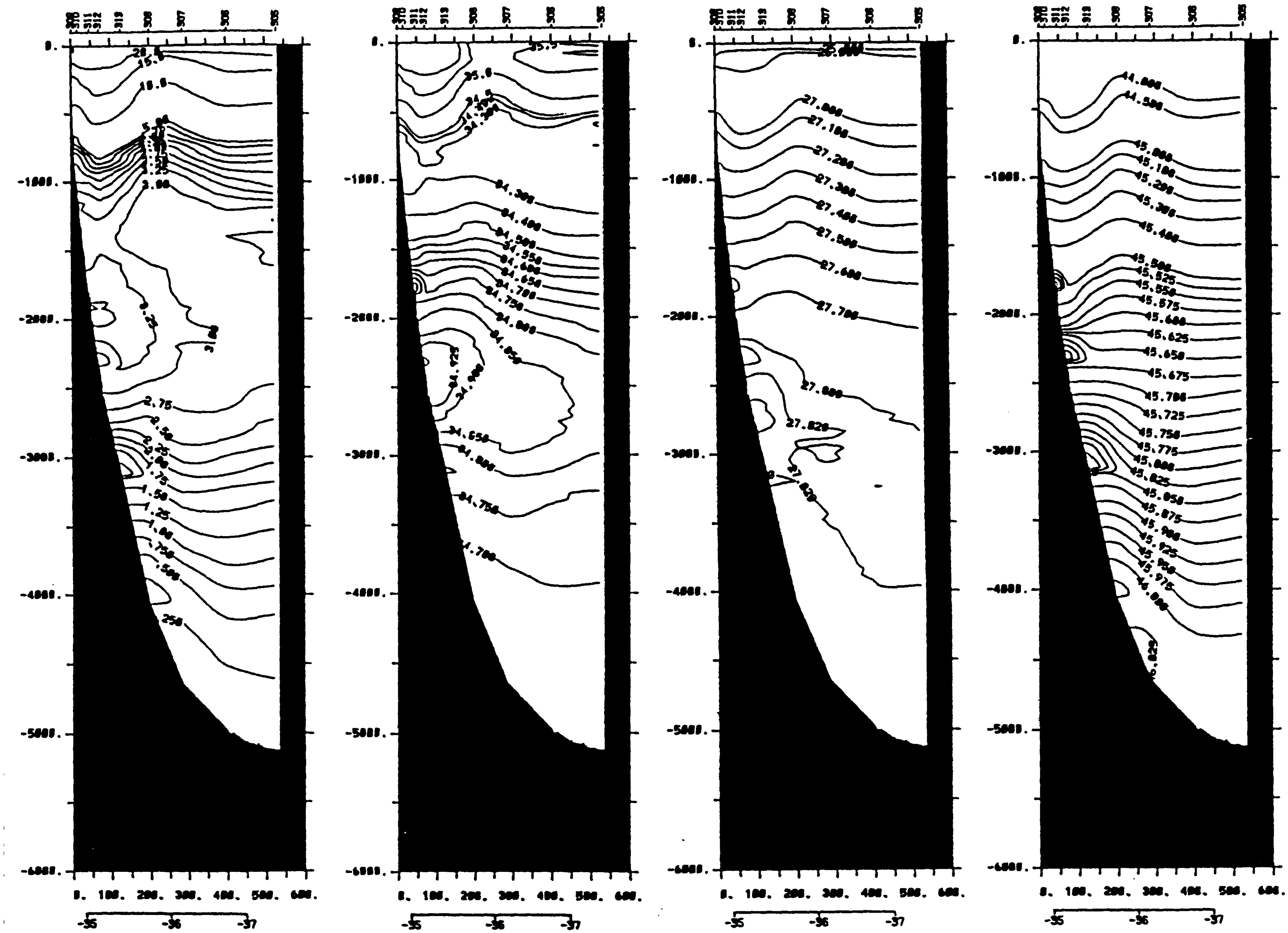
Phosphate (µm/l)



Nitrate (µm/l)

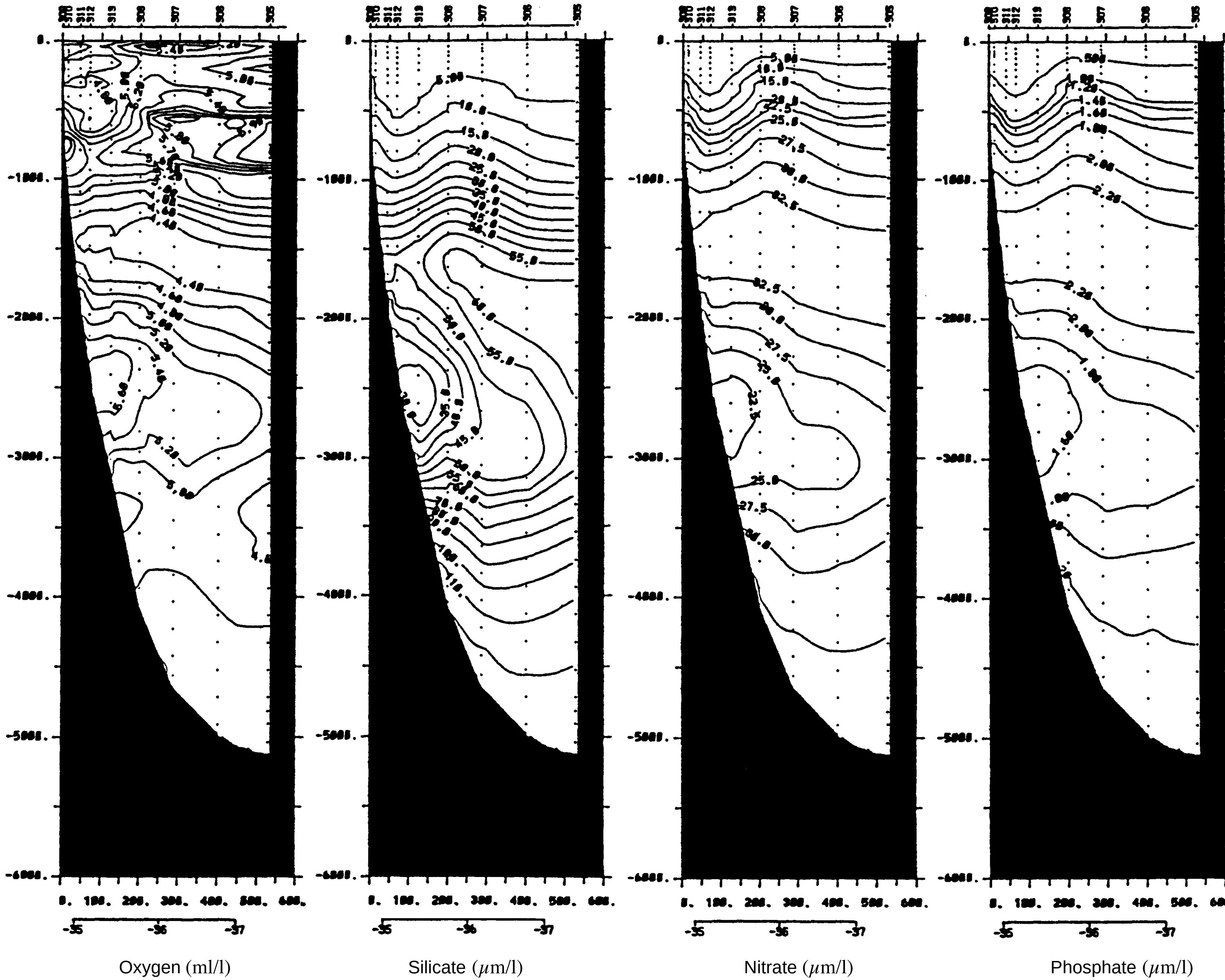


Silicate (µm/l)

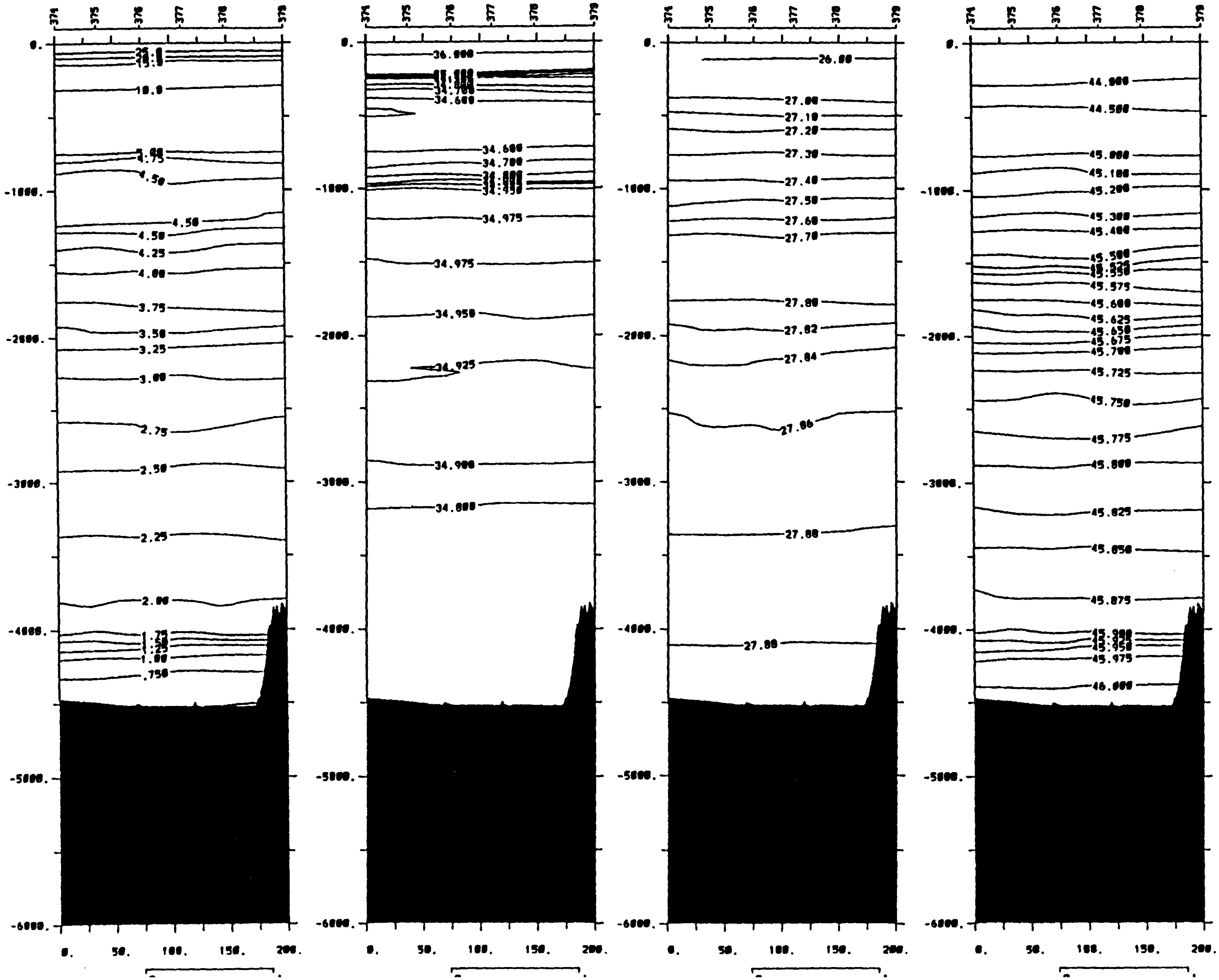


Potential Temperature (°C) | Salinity (‰) | σ_θ | σ_4

Vertical sections of CTD data from Brazil Current portion of Hydros 3 and 4 (Potential Temperature, Salinity, σ_θ and σ_4. The objective maping routine causes the fallacious extrema at the boundary.

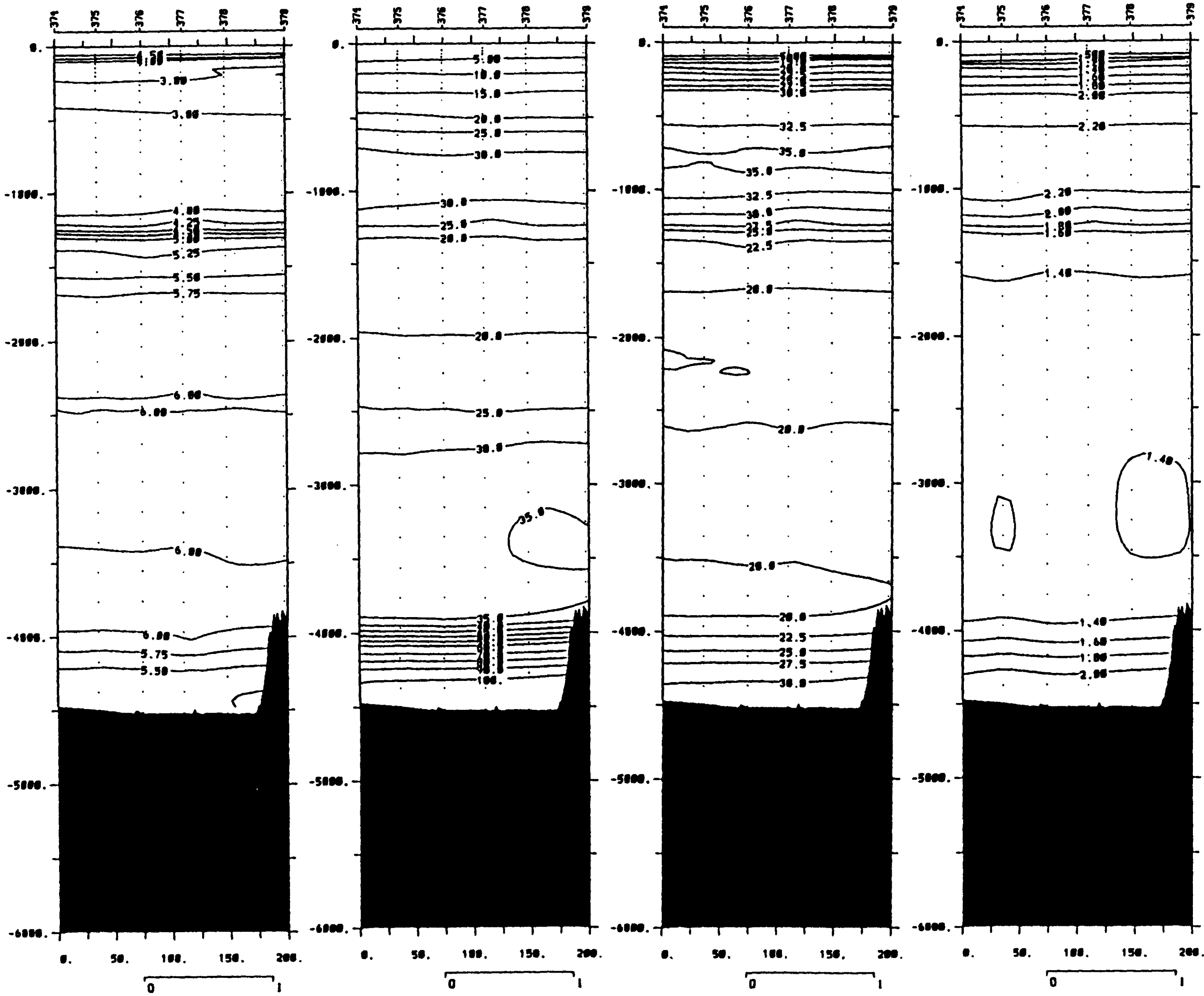


Vertical sections of Niskin data from the Brazil Current portion of Hydros 3 and 4 (Oxygen, silcate, nitrate, phosphate.)



Potential Temperature (°C) Salinity (‰) σ_θ σ_4

Vertical sections of CTD data along 35°W from Hydros 4



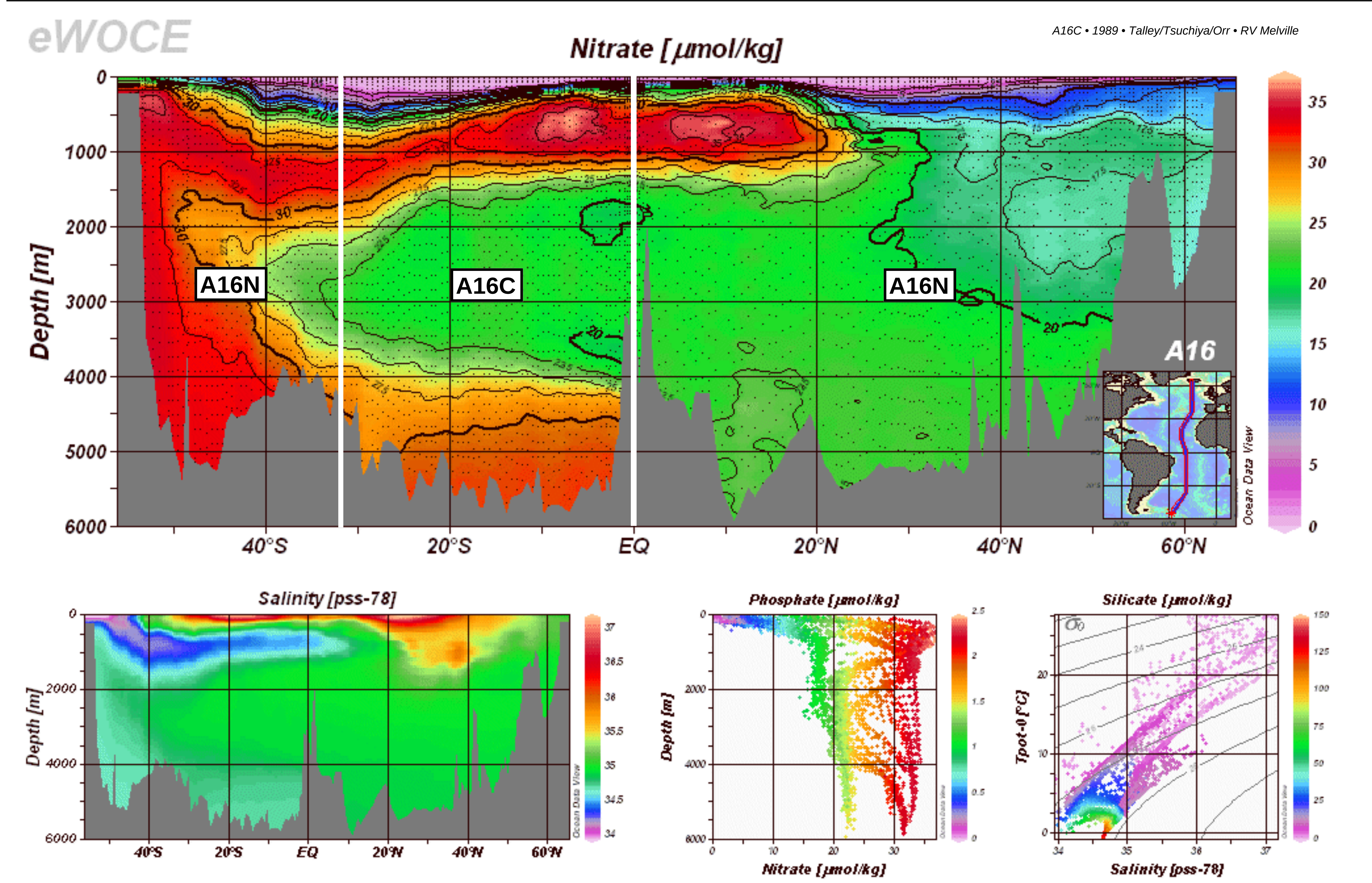
oxygen (ml/l)

Silicate (µm/l)

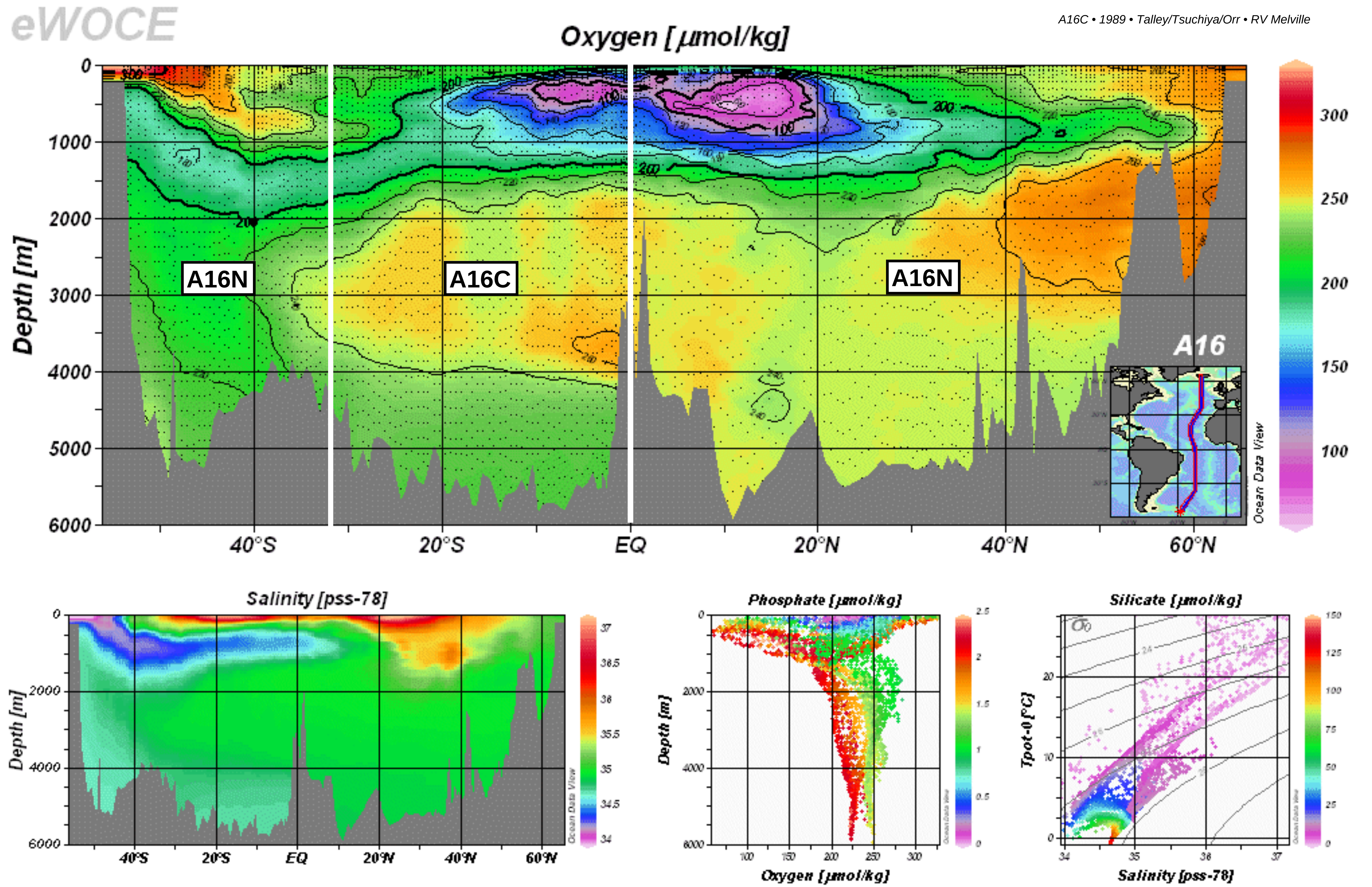
Nitrate (µm/l)

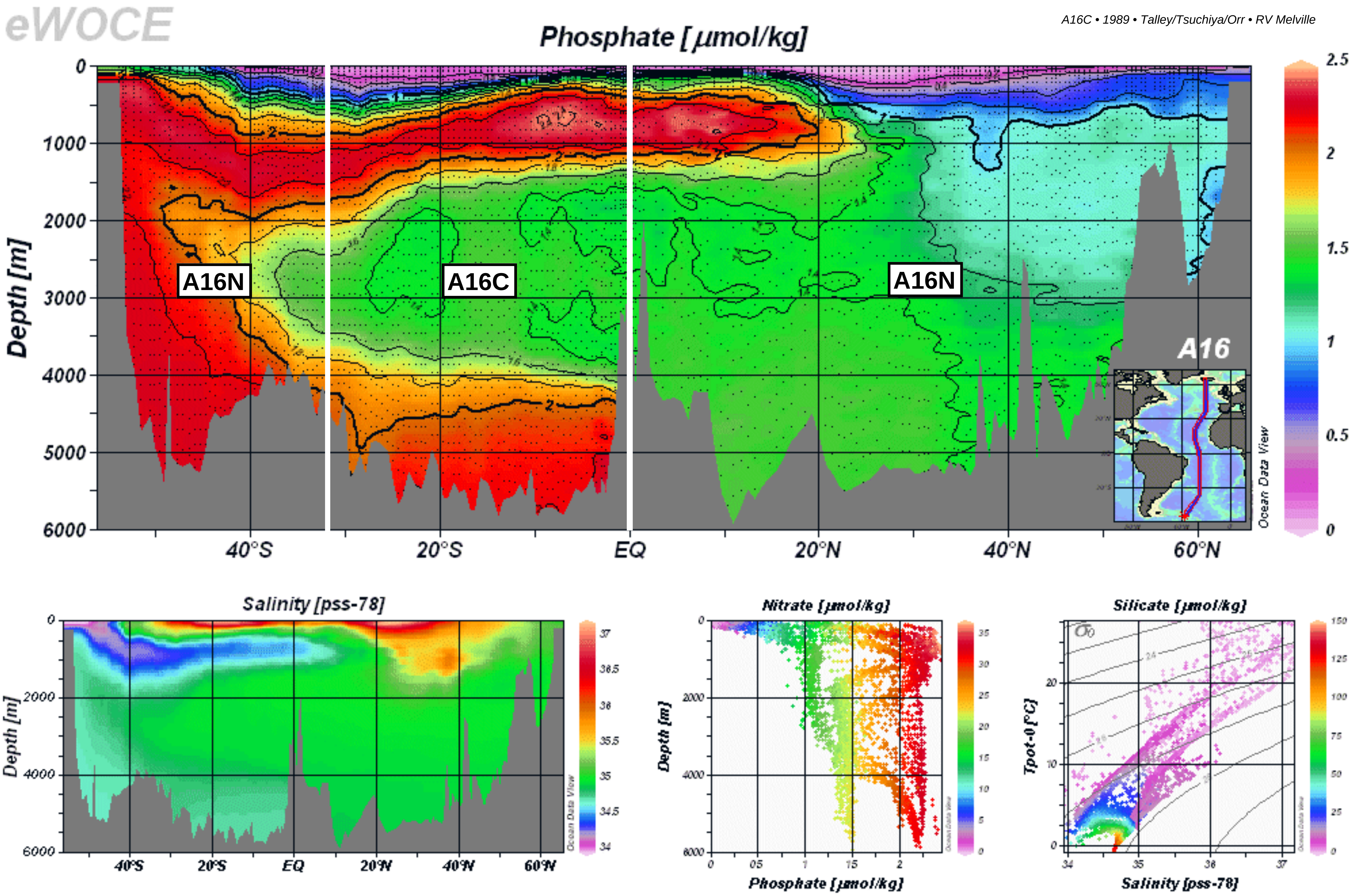
Phosphate (µm/l)

Vertical sections of Niskin data along 35°W from Hydros 4

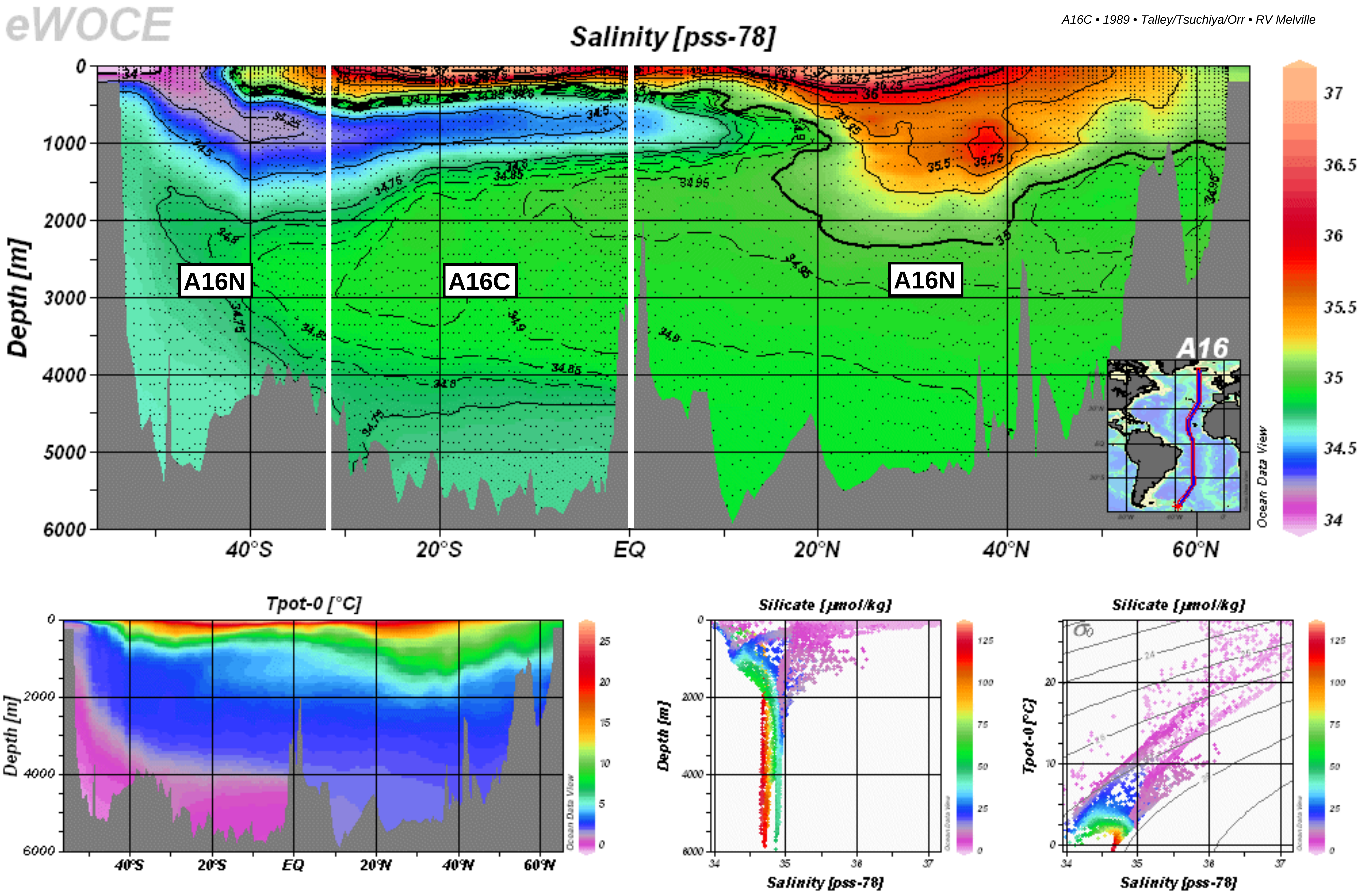


eWOCE
A16C • 1989 • Talley/Tsuchiya/Orr • RV Melville
Nitrate [µmol/kg]
Depth [m]
A16N
A16C
A16N
A16
Ocean Data View
40°S
20°S
EQ
20°N
40°N
60°N
Salinity [pss-78]
Phosphate [µmol/kg]
Nitrate [µmol/kg]
Silicate [µmol/kg]
Tpot-0 [°C]
Salinity [pss-78]


eWOCE
A16C • 1989 • Talley/Tsuchiya/Orr • RV Melville
Oxygen [µmol/kg]
Depth [m]
A16N
A16C
A16N
A16
40°S
20°S
EQ
20°N
40°N
60°N
Ocean Data View
Salinity [pss-78]
Phosphate [µmol/kg]
Oxygen [µmol/kg]
Silicate [µmol/kg]
Tpot-0 [°C]
Salinity [pss-78]
σ0



eWOCE
A16C • 1989 • Talley/Tsuchiya/Orr • RV Melville
Phosphate [µmol/kg]
Depth [m]
A16N
A16C
A16N
A16
40°S
20°S
EQ
20°N
40°N
60°N
Ocean Data View
Salinity [pss-78]
Nitrate [µmol/kg]
Phosphate [µmol/kg]
Silicate [µmol/kg]
Tpot-0 [°C]
Salinity [pss-78]


eWOCE
A16C • 1989 • Talley/Tsuchiya/Orr • RV Melville
Salinity [pss-78]
Depth [m]
A16N
A16C
A16N
A16
Ocean Data View
40°S
20°S
EQ
20°N
40°N
60°N
Tpot-0 [°C]
Depth [m]
Silicate [µmol/kg]
Depth [m]
Salinity [pss-78]
Silicate [µmol/kg]
Tpot-0 [°C]
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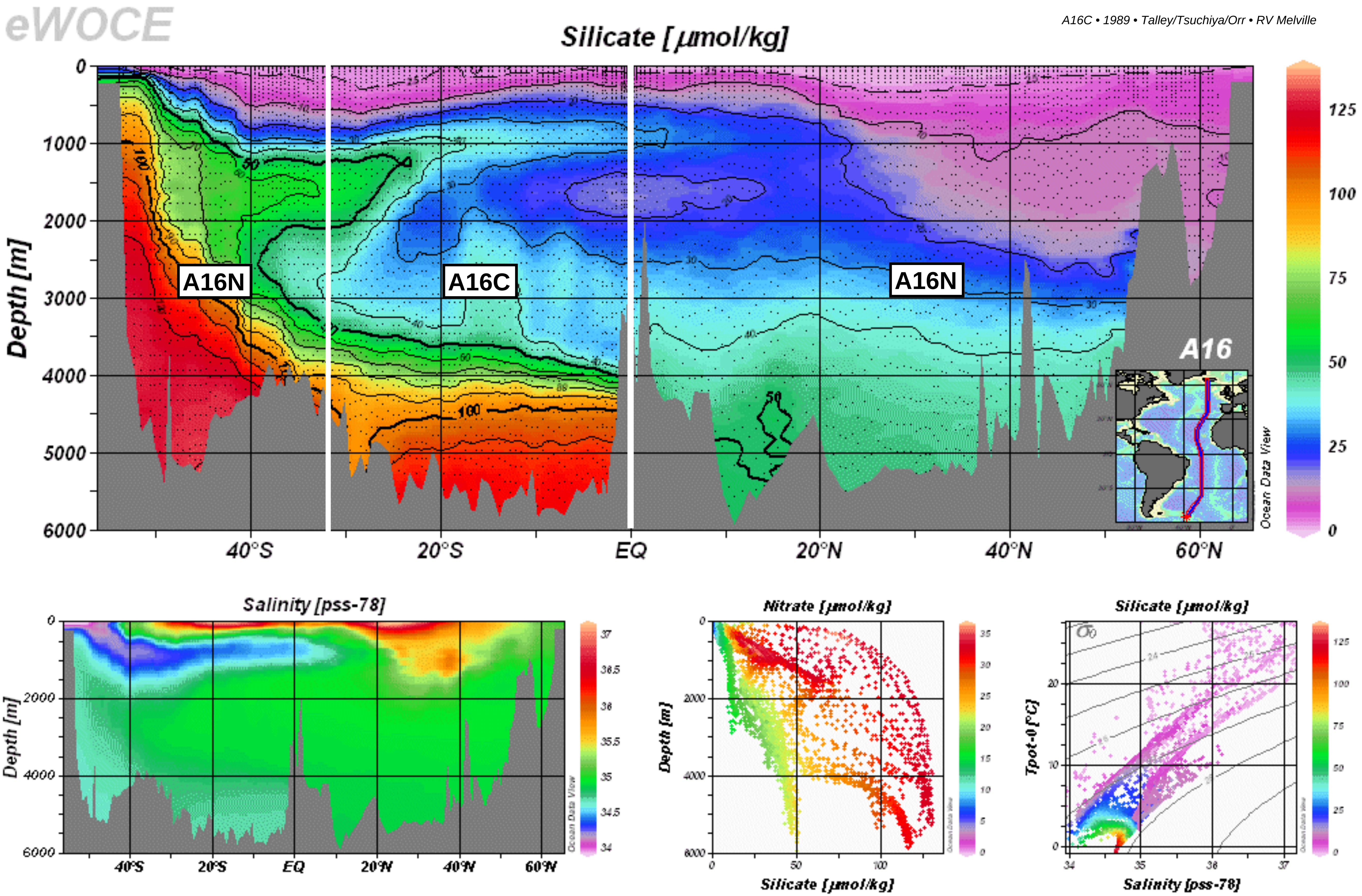
eWOCE
A16C • 1989 • Talley/Tsuchiya/Orr • RV Melville
Silicate [µmol/kg]
Depth [m]
A16N
A16C
A16N
A16
40°S
20°S
EQ
20°N
40°N
60°N
Ocean Data View
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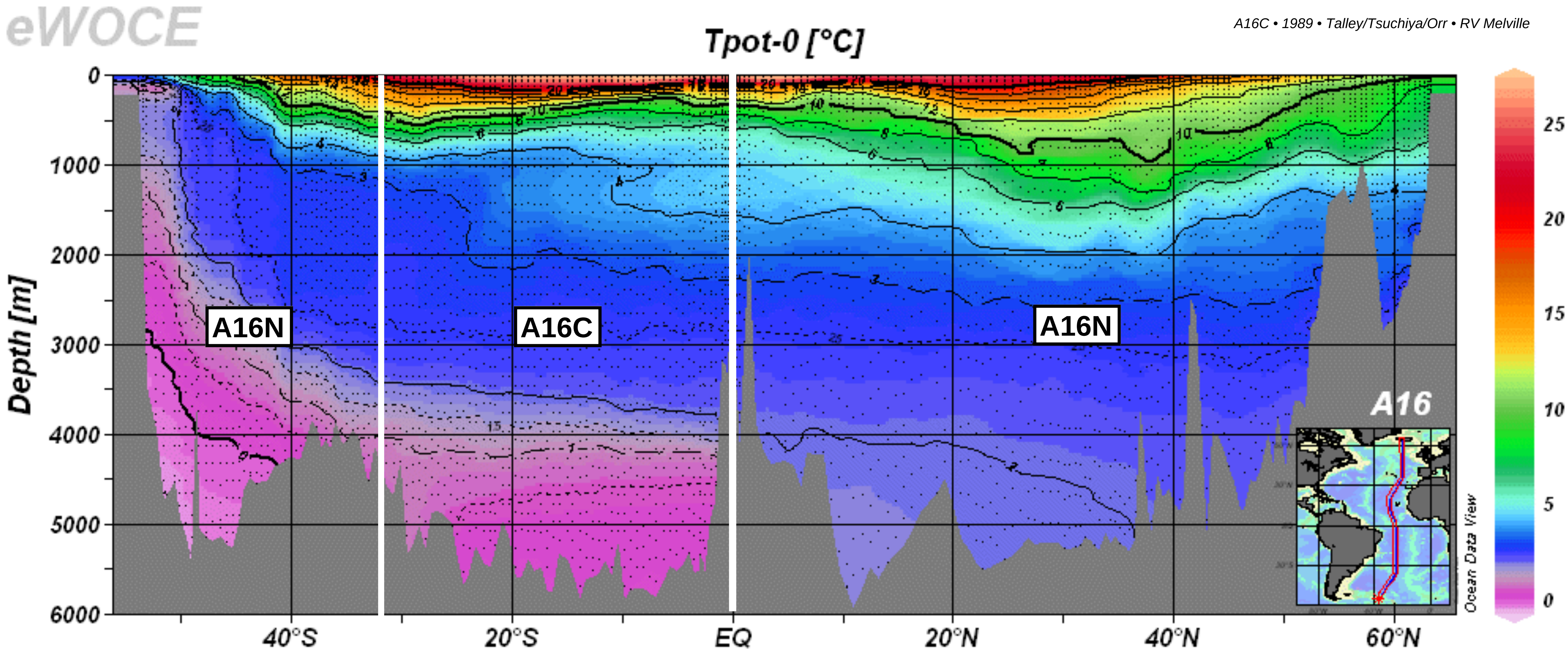
Nitrate [µmol/kg]
Silicate [µmol/kg]
Salinity [pss-78]
Tpot-0 [°C]


eWOCE
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Tpot-0 [°C]
Depth [m]
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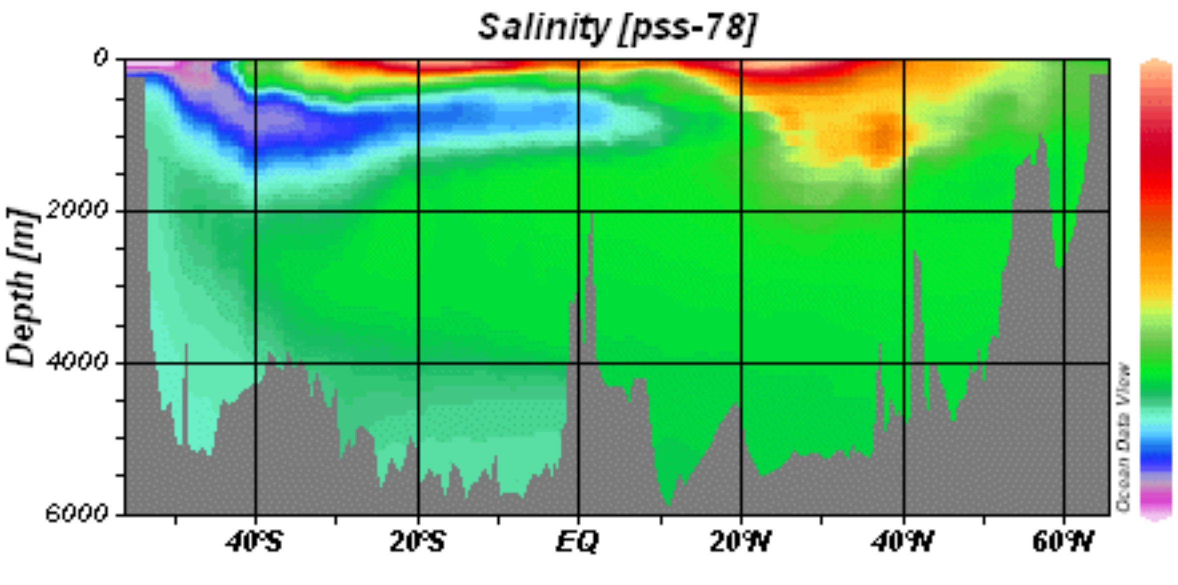
A16C
A16N
A16
40°S
20°S
EQ
20°N
40°N
60°N
Ocean Data View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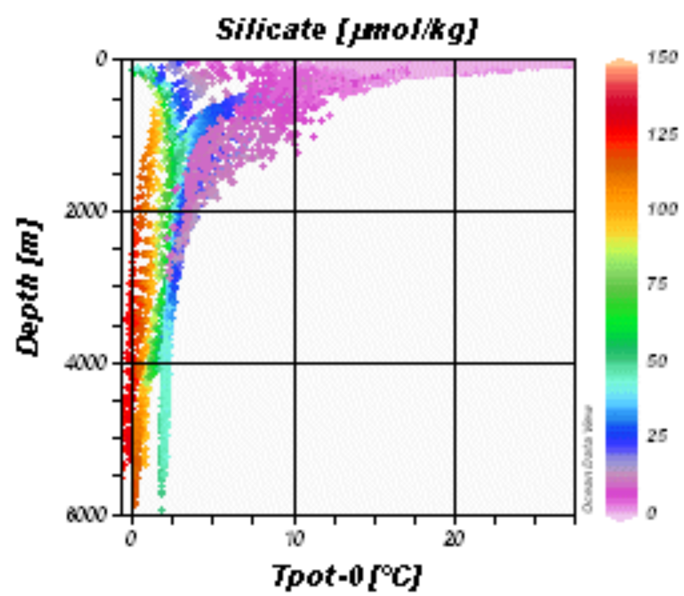
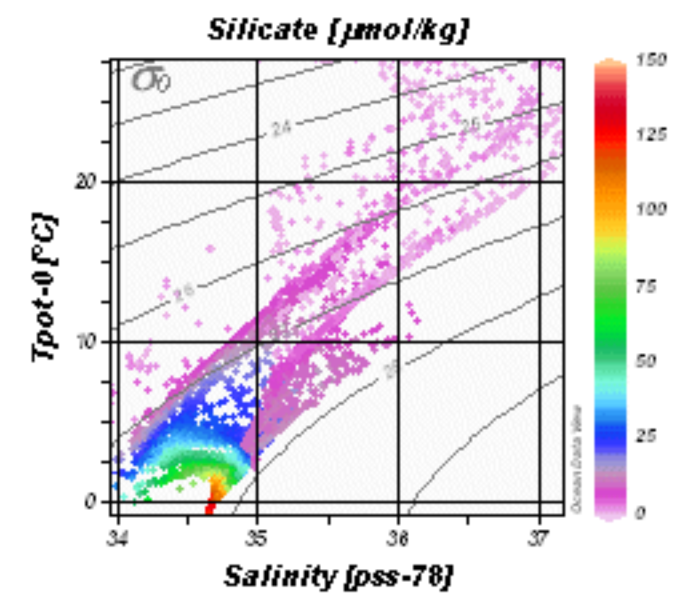
40°N
60°N


Silicate [µmol/kg]
Depth [m]
Tpot-0 [°C]


Silicate [µmol/kg]
Tpot-0 [°C]
Salinity [pss-78]

CCHDO-WHPO Data Processing Notes

Date	Contact	Data Type	Data Status Summary
02/27/98	Unknown	CTD/BTL/SUM	May be original submission
	Parameters Submitted: STNNBR CASTNO SAMPNO CTDPRS CTDTMP CTDSAL THETA SALNTY OXYGEN SILCAT NITRAT NITRIT PHSPHT QUALT1 Also Submitted: • Nav. File • Prelim. Cruise Report dated 6/16/92 • Station Plot		
04/16/99	Jenkins	He/Tr	Projected Submission Date: 1999.09.15
	(disk crash; must reprocess)		
08/26/99	Delahoyde	CTD/BTL/SUM	Data collected pre-WOCE
	Data collected before WOCE guidelines existed. This cruise was done before we had developed any WHP software. It was done with much older sensor calibration models, so we can't assess the accuracy of the data the way we do now. It goes without saying that there are no quality codes. We have the data available in their original ascii format (whpo:/whpo/3/a16ctd.tar.gz). This distribution includes the original documentation describing the data formats.		
08/31/99	Swift	CTD/BTL/SUM	Data acceptable as is
	Frank - Thanks. Yes, no problem with "pre-WOCE". We - well, Sarilee - can make these files into quasi-WOCE CTD format, and Jerry can integrate the documentation as needed. There were ODF South Atlantic A16 (25W) segments done for both Talley and Smethie. These are from the general "SAVE/HYDROS" era, I think. Thanks for getting us the CTD data in whatever form you have. We're happy to take it from there.		
03/07/00	Talley	CTD/BTL	Data are Public
	ctd data should be on website		
03/14/00	Weiss	CFCs	Data are Public
	These data were PUBLISHED in 1993 (Weiss et al., SIO Reference Series 93-49)		
05/31/00	Huynh	DOC	PDF & TXT cruise reports online
06/16/00	Talley	CTD	Submitted; not WOCE formatted

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HYDROS Leg 4 (SAVE-6, aka A16C) Corrected Pressure-Series CTD
Data (Pressure, Temperature, Conductivity/Salinity, Theta, Oxy

               Tape Format Description Document
                         May 3, 1991
                      STS/ODF CTD Group
                 Oceanographic Data Facility
               Scripps Institution of Oceanography
                 UC San Diego, Mail Code 0214
                      9500 Gilman Drive
                    La Jolla, CA  92093-0214
                     phone: (619) 534-1906
                      fax: (619) 534-7383
                    e-mail: odf@odf0.ucsd.edu
```

CCHDO-WHPO Data Processing Notes

1. MANIFEST

This distribution is contained on one 1200-foot, 1600 bpi, 9-track magnetic tape. All files consist of fixed-length, blocked ASCII records, with no embedded control characters. The tape is organized as follows:

HYDROS Leg 4 Corrected Pressure-Series CTD Data Distribution

File	Contents	Record Length	Block Size
1	This Document	80	4000
2	File Index	80	4000
3	Cast Description	80	4000
4-74	CTD Data (HYDROS-4)	80	4000

2. PROCESSING NOTES

The CTD data on this tape have been calibrated/corrected. Complete CTD data handling and processing information is detailed on separate documentation that accompanies this tape. Interpolated/extrapolated data records are identified by a count of "1" in the "number of raw frames..." reported with each record. Any blank data values are reported as "- on the tape.

Transmissometer data collected with the CTD data are not included on this tape. Wilf Gardner at Texas A&M University should be contacted regarding the status of these data.

Hydrographic data are not included on this tape: they will be distributed separately when finalized. The station-cast information on this CTD tape contains bottom depths in corrected meters. Various missing values (positions or depths) have been replaced by "-9" on this tape. Some positions and depths may yet be updated during finalization of hydrographic data.

3. FILE FORMATS

File 2 of this tape contains an index of all the files on this tape. It can be used to create a command file to load and name the data sets.

Index File Record Format

Parameter	FORTRAN Format
(First Record)	
Comment Line	a80
(Subsequent Records)	
File number	i3,1x
Data set name	a9

File 3, the Cast Description file, consists of one title record, followed by one record for each cast from the cruise. Non-CTD cast descriptions are also included in this file for convenient reference. The records have the following formats:

CCHDO-WHPO Data Processing Notes

Cast Description Record Format

Parameter	FORTRAN Format
(First Record)	
Cruise Name	a25
Ship Name	a25
Cruise Dates	a25
(Subsequent Records)	
Leg	3x,i2
Station	2x,i3
Cast	3x,i2
Day	i2
Month	i2
Year	i2
Cast Type	2x,a3
Latitude Degrees	i2
Latitude Minutes	f4.1
Hemisphere (N or S)	a1
Longitude Degrees	i3
Longitude Minutes	f4.1
Hemisphere (E or W)	a1
GMT Time (hhmm)	i4
PDR Bottom Depth (meters)	i5
Remarks (CTD#, distance above bottom, misc. info.)	a30

The CTD data on files 4-74 consist of one two-decibar pressure-series data set for each cast. Each data set consists of one cast description header record, followed by one fixed-length data record per 2-decibar pressure interval. The record formats are as follows:

CTD Data Record Format

Parameter	FORTRAN Format
(First Record)	
Cast Description Record	(see file 3 format)
(Subsequent Records)	
Pressure (decibars)	f6.1
Temperature (degrees C, IPTS-68)	1x,f7.4
Conductivity (milli-mhos/cm)	1x,f7.4
Salinity (PSU, PSS-78)	1x,f7.4
Potential Temp. (degrees C, IPTS-68)	1x,f7.4
Dissolved Oxygen (ml/l)	1x,f5.2
Number of Raw Frames in Average	1x,i4
Blanks to pad to 80 characters	31x

CCHDO-WHPO Data Processing Notes

```
SAMPLE DATA FILE:
(50% of file 4, first tape block:  HYDROS-4, station 309 cast 1)

4  309    1140389  ROS3443.7S 52 0.9W1747  261CTD#1, 12 btls  dab=8
         0.0 25.0643 53.8995 35.5697 25.0643  5.67   12
         2.0 25.0664 53.9827 35.6292 25.0659  5.48  164
         4.0 25.0632 54.0019 35.6454 25.0623  4.85  169
         6.0 25.0657 54.0066 35.6463 25.0644  4.84   91
         8.0 25.0635 54.0083 35.6485 25.0618  4.84   81
        10.0 25.0642 54.0117 35.6498 25.0621  4.96   90
        12.0 25.0724 54.0175 35.6471 25.0697  4.95   99
        14.0 25.0520 54.0125 35.6588 25.0490  4.93   60
        16.0 25.0230 54.0164 35.6840 25.0196  5.02  155
        18.0 24.9990 54.0592 35.7342 24.9950  4.91   62
        20.0 25.0047 54.1984 35.8326 25.0004  5.04   94
        22.0 24.9954 54.4737 36.0446 24.9906  4.95  107
        24.0 24.9165 54.6012 36.2023 24.9113  4.91   52
        26.0 24.9233 54.7246 36.2883 24.9177  5.04  155
        28.0 24.9055 54.8928 36.4278 24.8995  4.94   57
        30.0 24.9408 55.0781 36.5372 24.9343  5.07  135
        32.0 24.9914 55.1964 36.5840 24.9844  4.83   60
        34.0 25.0149 55.2660 36.6163 25.0075  4.99  108
        36.0 25.0381 55.3314 36.6456 25.0302  5.00   95
        38.0 25.0362 55.3315 36.6467 25.0279  5.02  112
        40.0 25.0344 55.3313 36.6473 25.0256  4.99   76
        42.0 25.0352 55.3355 36.6491 25.0260  5.06   95
        44.0 25.0944 55.4542 36.6889 25.0848  5.02  125
        46.0 25.1173 55.5068 36.7090 25.1072  4.79   74
```

07/06/00	Anderson	CTD/SUM	Data Reformatted to conform to WOCE standards

- Reformatted .sum file.
- Reformatted CTD files, added correct headers. Used 2 for all QUALT codes.
- CTD files had day as 10 for stas. 374 and 375.
- .sum file had 11 for the day. I changed the ctd files to agree with the .sum file.

07/10/00	Huynh	DOC	Website Updated; New cruise reports online

Both pdf and text docs have been updated and are online.

07/10/00	Bartolacci	CTD/SUM	Website Updated; new files online

Replaced newly reformatted CTD and SUM files (reformatted by S. Anderson). All entries and tables have been updated.

10/11/00	Uribe	SUM	Submitted

Files were found in incoming directory under whp_reports. This directory was zipped, files were separated and placed under proper cruise. All of them are sumfiles.

Received 1997 August 15th.

11/08/00	Uribe	CTD	File split into a16c and a16s files

- Directory a16ctd.tar was moved from ftp-incoming.2000.10.23/
- Was decompressed into two sub-directories A16C and A16S.
- Data contained in both directories is CTD.
- Directory was received June 16th, 2000.
- Website indicates data are public.

CCHDO-WHPO Data Processing Notes

Date	Contact	Data Type	Data Status Summary
04/03/01	Diggs	CFCs	Submitted
	CFC data submitted by Peter Salameh @ SIO. Placed files in data/onetime/atlantic/a16/onetime		
04/16/01	Muus	CFCs/SUM	CFC data merged into BTL file, new SUM file made
	Notes file for A16C modification and final CFC merging. SAVE Leg6/HYDROS Leg 4 R/V MELVILLE April 16, 2001 D. Muus 1. Generated new SUMMARY file from final SIO/ODF data. Now has Uncorrected as well as Corrected Bottom Depths, corrected EVENT CODEs, NAV, Height ABOVE BOTTOM, WIRE OUT, MAX PRESS, NO. OF BOTTLES, complete parameter numbers from Sample Log Sheets and COMMENTS from ODF Station and Cast Description. Particulates were not included since the Sample Logs are incomplete and do not say whether they were parameter number 40 or 41 (or both). 2. Generated new SEA file from final SIO/ODF data. Now has BTLNBRs, complete CTDSAL and more decimal places in data. ODF did not include CTDOXY with bottle data in pre-WOCE cruises so it is not available for this report. Oxygen is included with the CTD data. 3. Merged final CFC data received from Peter Salameh April 3, 2001: /usr/export/html-public/data/onetime/atlantic/a16/original/ A16_SAVE_CFC/save6.txt into the new SEA file, replacing the shipboard CFCs in the ODF data.		
4/16/01	Muus	CFCs	Reformatted by WHPO
	The modified a16c and a16s data are in ~dave/SDIGGS/A16. I was wrong in my April 3rd message assuming the .SEA files were from ODF. They look more like they were generated from .sd2 files. I redid everything from the final ODF data: .SUM files, .SEA files for rosette and .SEA files for large volume samplers. Freons were collected from the piggyback Niskins on many of the Large Volume casts. Many of the CFCs have quality codes of 6 meaning they are averages of replicate samples. The WOCE instructions say the details on the replicates should be in the documentation. I haven't seen any such documentation, could it be in the original CFC data directory in "a16_save_cfc.mail"? The read permission is 'owner only'. We do not have any of the actual large volume data (c14, argon-39, krypton, radium 228 & 226). The new files included them in the .SUM parameters but do not have any headers in the .SEA files. Successfully ran sumchk and wocecvt.		
06/20/01	Uribe	BTL	Website Updated; CSV File Added
	Bottle file in exchange format has been linked to website.		
06/21/01	Uribe	CTD/BTL	Website Updated; CTD CSV File Added
	BTL CSV file modified The exchange bottle file name in directory and index file was modified to lower case. CTD exchange files were put online.		

CCHDO-WHPO Data Processing Notes

Date	Contact	Data Type	Data Status Summary
	Key	DELC14	Website Updated; PI names corrected

The PIs for C14 during SAVE/HYDROS were Broecker/Ostlund.

The summary table shows No Data for A16C or A16S. I can provide copies of the LV files for all of SAVE/HYDROS if you do not have. I do not have Jenkin's (not Smethie) H3/He3 data for these cruises.

I should be listed as PI for A20 C14. These samples should get measured this year.

Date	Contact	Data Type	Data Status Summary
08/27/01	Swift	He/Tr	Data Request

HE/TR data requested by J Swift WHPO records indicate he/tr data not yet submitted. Request for earliest possible submission sent to Bill Jenkins.

Date	Contact	Data Type	Data Status Summary
09/16/01	Diggs	BTL/SUM	Website Updated; CSV files online

- New and files online
- Replaced both the SUM and BOTTLE files online with the ones with CFC values (Muus 20010416).
- Also placed LVS file online, produced EXCHANGE file and placed on website. EXCHANGE file verified w/ JOA v3.0.

Date	Contact	Data Type	Data Status Summary
11/12/01	Key	BTL/SUM	Submitted Large Volume Data

I uploaded the SAVE+HYDROS LV files today using your form.

Note that a bottle number of "99" is a surface sample obtained without using a Gerard barrel. The file I sent does NOT have the piggyback Niskin bottles. The only way I have that information is in a merged ascii file with "everything". This merged file does not have flags and is closer to the original files sent out by ODF + merged data I received from individual investigators. I have attached a copy of this file "just in case". The attached file is in an shortened format, but your guys won't have any trouble doing a reformat.

The file: SAVE.dat - 209411 bytes has been saved as:

20011112.075818_KEY_SAVE 1_5; HYDROS_4_SAVE.dat

in the directory:

20011112.075818_KEY_SAVE 1_5; HYDROS_4

The data disposition is: Public

The bottle file has the following parameters:

CTDPRS, REVTMP, SALNTY, OXYGEN, SILCAT, NITRAT,
NITRIT, PHSPHT, C14, C14ERR, TCARBN, ALKALI

The file format is: Comma Separated Values
The archive type is: NONE - Individual File
The data type(s) is: Summary (navigation)
Bottle Data (hyd)

The file contains these water sample identifiers:

1. Cast Number (CASTNO)
2. Station Number (STATNO)
3. Bottle Number (BTLNBR)

CCHDO-WHPO Data Processing Notes

Date	Contact	Data Type	Data Status Summary
11/12/01	Key	BTL/SUM	Submitted Large Volume Data
	KEY, ROBERT would like the following action taken on the data: Place Data Online Any additional notes are: WOCE flags have been assigned and are included, however, the QC was NOT thorough, especially with respect to routine hydro data.		
12/20/01	Hajrasuliha	CTD	Data check done
	*check.txt created for this Cruise. Could not Create .ps files for this cruise.		
12/20/01	Uribe	CTD	Website Updated; CSV File Added
	CTD has been converted to exchange using the new code and put online.		
04/12/02	Buck	BTL	Data includes a16s data
	ctdprs, salnty, oxygen, silcat, nitrat, nitrit, phspht, revtmp, delc14, tcarbn, alkali, c14err Copied this directory from: /usr/export/html-public/cgi/SUBMIT/INCOMING/20011112.075818_KEY_SAVE \2401_5;\240HYDROS_4. Had to rename the two files to take care of strange characters in the name. The data contains of a readme file from the data submission website and a CSV bottle file. This data is the same as that which was copied into the same directory name in A16S/original.		
08/21/02	Anderson	PCO2	Merged CO2 data into online file, made exchange file
	Data merged into online file. Merged the TCARBN, PCO2, and PCO2TMP into online file. Made new exchange file. Merge notes on a16c: • Retrieved the carbon data for a16c from the CDIAC website re Kozyr's Aug. 14, 2002 e-mail. • Merged the TCARBN, PCO2, and PCO2TMP into the online file.		
09/02/04	Kappa	DOC	Cruise report updated
	1. added Section 3: CTD Data Collection, Analyses and Processing 2. added APPENDIX A: HYDROS Leg 4 CTD Processing Notes (table) 3. added APPENDIX B: Bottle Data Processing Notes 4. added Table 2: HYDROS-4 XBT station positions 5. added Vertical Section Plots: • Potential temperature (°C) • Salinity • σ_θ • σ_4 • Oxygen (ml/l) • Phosphate (µm/l) • Nitrate (µm/l) • Silicate (µm/l) • Vertical sections of CTD data from Brazil Current portion of Hydros 3 and 4 (Potential Temperature, Salinity, σ_θ and σ_4. The objective mapping routine causes the fallacious extrema at the boundary.		

CCHDO-WHPO Data Processing Notes

09/02/04	Kappa	DOC	Cruise report updated (continued)

- Vertical sections of Niskin data from the Brazil Current portion of Hydros 3 and 4 (Oxygen, silcate, nitrate, phosphate)
- Vertical sections of CTD data along 35°W from Hydros 4
- Vertical sections of Niskin data along 35°W from Hydros 4

6. added CCHDO/WHPO-generated station track
7. added these Data Processing Notes